Eleventh Edition

BOATING

SKILLS & SEAMANSHIP

U.S. Coast Guard Auxiliary

YOU ARE CORDIALLY INVITED...

CONGRATULATIONS on your decision to take this safe boating course. It can help your boating enjoyment and safety. The knowledge of seamanship and the navigation rules you will gain will give safe boating new meaning for you. It will offer you many hours of pleasure.

The people who teach this course are boaters much like you. Many of them began boating after a course such as this one. Through the United States Coast Guard Auxiliary, they have gained additional experience and knowledge. If you would like to learn more about safe boating and to share your knowledge with others, please consider joining us.

The Auxiliary is the volunteer civilian, non-military component of the United States Coast Guard. Auxiliarists serve side-by-side with members of the Coast Guard and wear similar uniforms. We are a diverse group of about 40,000 people. Our love of the water, knowledge of boating, and willingness to serve fellow boaters binds us together to promote safe boating.

After you have successfully completed this course, you can become a member of the Auxiliary if you are a U. S. citizen who is at least 17 years old. In addition, you must own at least a 25 percent interest in a boat, an aircraft, or a marine radio station. Even if you do not have one of these, you can still join if you have a special skill needed by the Auxiliary. Application forms are in the back of this book and in the *Student Study Guide.* You also can get one from your course supervisor.

In the 1930s, as today, most calls for help resulted from boaters' lack of basic seamanship knowledge or ignorance of the law. As a result, the Coast Guard, which is responsible for maintaining pleasure boat safety standards, decided it needed a new approach to the problem of water safety. Thus, the United States Congress in 1939 established what was to become the Auxiliary to help promote water safety. In 1941, Congress gave it the title of the United States Coast Guard Auxiliary.

The Auxiliary built its foundation on four cornerstones, Public Education, Vessel Examination, Operations, and Fellowship. The Vessel Examination program offers boaters free, annual checks of their boats' safety equipment and a general view of other equipment. Its Operations program helps in search and rescue efforts, regatta patrols, boat parades, and other similar efforts. Its Public Education courses reach people in all age groups.

The Vessel Examination and Public Education programs help prevent problems. Operations also seeks to prevent problems, but when needed, it does search and rescue (SAR) missions. We think of our Public Education program as preventive SAR. Members use their boats, aircraft, or marine radio stations for SAR missions. They equip them at their own expense. The Coast Guard repays them for fuel used in Operations and for any damage to their facilities while on missions.

The fourth cornerstone, Fellowship, binds us together. All work and no play make for a dull organization, and the Auxiliary is not dull. We train together, work together on SAR and other missions, have social gatherings, and have area and national conferences where friendships are made and renewed at meetings, dinners, and parties.

The Coast Guard Auxiliary is a **Service Organization**. It requires time, financial support, and dedication to new knowledge. We give our time to train and to serve. We buy our own uniforms and equip our boats or aircraft. We have many opportunities for special training. The Auxiliary does much of this, and the Coast Guard gives us some help.

The "pay" is great. We get immeasurable satisfaction from our volunteer service. We take satisfaction in knowing that we are trained and able to meet the demands placed upon us. In the words of a National Commodore, "There is no greater satisfaction than service to a fellow human being, especially the saving of a life." The rewards of knowing that you have performed important services are many. The "thank you" received from a student or from a boater whom you have helped makes it worthwhile.

There is a place for YOU in the Coast Guard Auxiliary. Please consider joining us. You are eligible once you have completed this course. Make it a family affair. We need both women and men.

BOATING SKILLS & SEAMANSHIP

Eleventh Edition

U.S. COAST GUARD AUXILIARY

Copyright© 1995
Coast Guard Auxiliary National Board Inc.
Washington, D. C.
All rights reserved.

First Edition	1971
Second Edition	1972
Third Edition	1972
Fourth Edition	1973
Fifth Edition	1974
Sixth Edition, First Printing	1975
Sixth Edition, Second Printing	1976
Seventh Edition	1977
Eighth Edition	1979
Ninth Edition, First Printing	1982
Ninth Edition, Second Printing	1983
Ninth Edition, Third Printing	1984
Ninth Edition, Fourth Printing	1986
Tenth Edition, First Printing	1988
Tenth Edition, Second Printing	1988
Tenth Edition, Third Printing	1990
Eleventh Edition	1995

This book, or any part thereof, may not be reproduced
without written permission of the copyright owner.

Library of Congress Catalog Card Number: 74-164-688
ISBN 0-930028-03-01
Printed in the United States of America
at no cost to the
United States Government or
United States Coast Guard

Contents approved by the
National Association of
State Boating Law Administrators
and recognized by the
United States Coast Guard

Table of Contents

Foreword ... ix

Preface ... xi

Introduction ... xiii

Chapter 1 WHICH BOAT IS FOR YOU?

Boaters' Language ... 1-1
Types of Boats ... 1-2
Outboard Motors and Stern Drives ... 1-3
Hull Design ... 1-4
Uses of Boats ... 1-5
Other Power Plants ... 1-8
Materials for Constructing Boats ... 1-8
Your Intended Use ... 1-11
The Coast Guard Customer Infoline ... 1-11
Marine Surveyors ... 1-12
Buying a Boat ... 1-12

Chapter 2 EQUIPMENT FOR YOUR BOAT

Requirements for Your Boat ... 2-1
Your Boat's Equipment ... 2-7
Legal Considerations ... 2-18
Substance Abuse ... 2-20
Boating Accident Reports ... 2-21
Courtesy Marine Examinations ... 2-21

Chapter 3 TRAILERING YOUR BOAT

Legal Considerations ... 3-1
Practical Considerations ... 3-3
The Towing Vehicle ... 3-8
Balancing the Load ... 3-10
Handling Your Trailer ... 3-11
Pre-Departure Checks ... 3-12
Preparing to Launch ... 3-12
Launching ... 3-13
Retrieving ... 3-14
Storing Your Boat and Trailer ... 3-14
Theft Prevention ... 3-15
Zebra Mussels ... 3-17
Float Plan ... 3-17

Chapter 4

HANDLING YOUR BOAT

Leave With a Full Fuel Tank 4-1
Fueling Your Boat 4-1
Your Boat's Propeller 4-3
Cars and Boats 4-4
Twin Screws 4-6
Installation and Tilt Adjustment 4-7
Jet Drives 4-8
Loading Your Boat 4-8
Getting Started 4-9
Leaving a Pier 4-11
"Man" Overboard 4-14
Docking 4-15
Mooring to a Permanent Anchor 4-16
Anchoring 4-17
Towing a Skier 4-21
Heavy Weather 4-22
Small Boat Safety 4-24

Chapter 5

YOUR "HIGHWAY" SIGNS

Protection of ATONs 5-1
Buoyage Systems 5-1
Waterway Marks 5-3
How Waterways are Marked 5-6
Light Characteristics 5-10
Chart Symbols 5-11
Light Structures 5-12
Lights on Bridges 5-14
Electronic Aids to Navigation 5-14
A Word To The Wise 5-16
Navigation Publications 5-16

Chapter 6

THE RULES YOU MUST FOLLOW

Two Sets of Rules 6-1
To Whom Do the Rules Apply? 6-2
What is a Vessel? 6-2
The General Responsibility Rule 6-3
General Considerations 6-3
Conduct in Narrow Channels 6-4
Traffic Separation Schemes 6-4
Vessel Traffic Services 6-5
Stand-On or Give-Way? 6-5
Rules for Special Vessels 6-6
Risk of Collision 6-7
Bend Signals 6-12
Restricted Visibility 6-13
Vessel Lights and Shapes 6-13
Vessels at Anchor 6-19
Diving Operations 6-19
Distress Signals 6-20
Drawbridge Signals 6-20
Penalties 6-21

Chapter 7

PILOTING YOUR BOAT

Piloting Tools 7-1
Maps and Charts 7-2
Chart Features 7-2
Your Chart's General Information Block 7-4
Other Charted Information 7-6
Your Magnetic Compass 7-7
Position On the Earth's Surface 7-8
Locating a Point On a Chart 7-10
Distance On the Earth's Surface 7-10
Measuring Distance 7-11
Course Plotting 7-12
Sources of Compass Error 7-13
Correcting a Compass Reading 7-14
Positioning 7-15
Speed-Time-Distance 7-17
Dead Reckoning 7-19
Practice Your Art 7-20

Chapter 8

POWERING YOUR BOAT

Types of Marine Engines 8-1
Marine Engines 8-3
Selecting a Propeller 8-5
Induction Systems 8-6
Ignition Systems 8-6
Flame Arresters 8-7
Cooling Systems 8-7
Gasoline Considerations 8-8
Batteries 8-10
Maintenance 8-14
Winterizing Your Boat 8-17
Spring Fitting-Out 8-19
Troubleshooting 8-19

Chapter 9

LINES AND KNOTS FOR YOUR BOAT

Line or Rope? 9-1
Rope Materials 9-1
Kinds of Rope 9-3
Measuring Rope 9-4
Selecting Your Ropes 9-4
Care of Rope 9-5
Making Up Line 9-7
Knots, Bends, and Hitches 9-9
Splices 9-14
Securing Lines 9-16
Dipping the Eye 9-20

Chapter 10

WEATHER AND BOATING

Sources of Weather Information 10-1
Wind and Boating 10-3
Wind and Waves 10-3
Understanding Weather 10-4
Weather and Heat 10-4
Fog 10-11
Non-Frontal Weather 10-12

Chapter 11

YOUR BOAT'S RADIO

Radios Used On Boats 11-1
Functions of Radios 11-2
Licenses 11-3
Selecting Your VHF-FM Radio 11-4
Installation 11-6
Operating Your VHF-FM 11-7
Maintain a Radio Watch 11-7
Channels Have Special Purposes 11-8
Some No Nos 11-8
Copies Of The Rules 11-9
Calling Another Station 11-9
Procedure Words 11-10
Phonetic Alphabet 11-10
Routine Radio Check 11-11
Distress, Urgency, and Safety Calls 11-12
Crew Training 11-17

Chapter 12

INLAND BOATING

Types of Inland Waters 12-1
Inland Navigation 12-2
Inland Seamanship 12-5
River Currents 12-6
Maintaining Inland Waterways 12-8
Dams 12-10
Locks 12-14
River Charts 12-18
Commercial Traffic 12-22
Before You Go 12-24

Chapter 13

THE REST OF OUR STORY

Small Boat Safety 13-1
Personal Watercraft 13-3
Hypothermia 13-6
Motorboats and Sailboats 13-9
Carbon Monoxide Poisoning 13-15

Appendix A **Float Plan** A-1

Appendix B **U.S. Coast Guard District Offices** B-1

Appendix C **Instructions For Using a Course Plotter** C-1

Appendix D **Metric Conversion System** D-1

GLOSSARY Glossary-1

INDEX Index-1

PLATES .... Inside Back Cover

THE COMMANDANT OF THE UNITED STATES COAST GUARD
WASHINGTON, D.C. 20593-0001

FOREWORD

One of the primary roles of the United States Coast Guard is the promotion of recreational boating safety. As the National Recreational Boating Safety Coordinator, we do this in many ways -- by developing and enforcing safety standards in boat construction, through the review and approval of safety equipment, through education of the boating public, and through coordination of the boating safety efforts of the States and numerous nonprofit organizations.

An important step in improving boating safety was made in 1939 when the Congress of the United States chartered the organization that has become the Coast Guard Auxiliary. A primary mission of the Auxiliary is to help the Coast Guard promote recreational boating safety. The dedicated volunteers of the Auxiliary have worked shoulder to shoulder with the Coast Guard to achieve this goal. We owe a great debt to every member of the Auxiliary for their individual concern and their dedicated efforts to promote safe boating among our fellow citizens.

This text was prepared by the Coast Guard Auxiliary as a key component of its Boating Skills and Seamanship Course. It contains information that is vital to every boater and is provided for your benefit. This important course is just one of the Auxiliary's many public education courses, each of which is designed to help American boaters have safer public waterways and enjoy more pleasurable boating experiences.

I heartily endorse this course for everyone who uses our country's waters for recreational boating.

Robert E. Kramek.

ROBERT E. KRAMEK
Admiral, U. S. Coast Guard

UNITED STATES COAST GUARD
AUXILIARY

OFFICE OF THE
NATIONAL COMMODORE

PREFACE

The mission of the United States Coast Guard Auxiliary is to assist the Coast Guard in the performance of its civil functions, one of which is the promotion of recreational boating safety. The Auxiliary does this through its public education, vessel examination, and operations programs.

This book is the core text for one of the public education courses taught by the Auxiliary—Boating Skills and Seamanship. The course is one component of a well developed educational program that reaches from preschool through adulthood. The program is the most comprehensive available for today's pleasure boaters.

This 11th Edition of *Boating Skills and Seamanship* is produced without cost to the Coast Guard or the United States Government. It has been completely revised and updated from previous editions and it's content reviewed and approved by the U.S. Coast Guard and the National Association of State Boating Law Administrators. The information contained herein is consistent with current knowledge and with federal regulations in effect at the time of printing. Indeed, many insurance companies discount boat insurance premiums for persons who successfully complete the course.

Members of the Auxiliary, a volunteer, civilian organization, teach the course. They are a well-prepared group of dedicated men and women who give freely of their time and talent. Their pay is the satisfaction of doing a good job and knowing that they have helped other people have safe and enjoyable boating experiences. I am confident that you will enjoy getting to know and interacting with the Auxiliary Instructors with whom you will have contact.

As you read through this book you will find references to other courses available to the public through the Auxiliary. After you have completed this course you are welcome to further your education by taking a more advanced one or you may want to further your basic boating knowledge by enrolling in the Sailing and Seamanship course.

May you have smooth seas, sunny skies, and safe passage as you enjoy the unparalleled fun and excitement of recreational boating.

Sincerely,

Peter W. Melera
National Commodore
United States Coast Guard Auxiliary

Introduction

Welcome aboard! The course you are about to take is designed to help you become a better recreational boater. Through it, we hope to teach you the knowledge and skills which you need to boat safely. With this knowledge, you can avoid problems and enhance your enjoyment of your on-the-water activities.

We also want to raise your awareness of what *might* happen to you so that you can prevent it. We hope to help you help yourself in case you have problems on the water. We hope, also, to help you help others should the need arise.

A Growing Recreational Activity

The number of people using recreational boats is increasing rapidly from year to year, and boating is changing. Today's boating is much different from the yachting of yesterday although yachting still exists. Today, most recreational boats are small, less than 20 feet long, and their number is growing rapidly. Boating has become an important recreational activity.

For most of us, boating means a fun way to pass a day or a weekend with our family and friends. We use boats for cruising, sightseeing, water skiing, hunting, fishing, swimming, diving, waterbiking, and other purposes.

The Need for Boating Safety

For some people boating experiences are not always pleasant. Boating, at times, involves injury, financial loss, and sometimes death. Considering the small amount of time we actually spend on the water, injury and death rates exceed those of many hazardous occupations.

Fortunately, injury and death rates are gradually declining. This has resulted, in part, from the efforts of the United States Coast Guard, the Coast Guard Auxiliary, the United States Power Squadrons, and state and local agencies. They have been effective in preventing boating accidents and in saving lives.

Fig. Intro-1. The Basic Principles of Good Seamanship Apply...

Fig. Intro-2. ...Regardless of the Size of the Boat...

Fig. Intro-3. ...or the Amount of Money It Cost.

Promoting Boating Safety

Among the factors that account for improved boating safety are: improved boater safety education, expanded law enforcement, safer boats, and greater awareness of the roles of alcohol and drugs in boating accidents. The purpose of this course is to promote safe boating. We emphasize this purpose throughout the text. In so doing, we have tried to use as little jargon as possible. We also have included only that which we believe is basic to safe boating.

The Course in Perspective

This course, Boating Skills and Seamanship (BS&S), is one of five multi-lesson courses offered by the Auxiliary to the public. Another course, which has much the same design and overlaps this course, is Sailing and Seamanship (S&S). In conjunction with the Power Squadrons, we offer Boating Safely; a course for teenagers, for those who hunt or fish, and for state licensure. We also offer Basic Coastal Navigation (BCN) and Advanced Coastal Navigation (ACN). Satisfactory completion of BS&S or S&S, or an equivalent course, is a prerequisite for either BCN or ACN. BCN is a short version of ACN.

Who Are We?

Your instructors for this course are members of the United States Coast Guard Auxiliary. The Auxiliary, chartered by the United States Congress more than 50 years ago, helps the Coast Guard make our waters safer for all boaters. We do this through our public education courses, surface and air patrols, and vessel examinations. Our surface and air patrols include things such as sundown patrols to aid stranded boaters, search and rescue activities, patrols for events such as parades and regattas, patrols to inspect and maintain aids to navigation, and others.

We are volunteers, and most of us are recreational boaters who joined the Auxiliary after taking courses such as this one. We want to share some of our experience and some of the special training we have received from the Coast Guard. The Coast Guard is our parent organization; we are members of the Coast Guard family.

We are civilians who have no military or law-enforcement duties or powers. We give freely of our time and energies to promote safe boating through the Auxiliary's activities.

Please read the invitation on the inside front cover of this book for more information. After that, if you want to know more about the Auxiliary, your instructor will be happy to talk to you.

The Course Format

This course can take a variety of formats, each dependent on local needs and resources.

Fig. Intro-4. The Members of the Coast Guard Auxiliary are Concerned Civilian Volunteers.

These formats can include as few as six lessons or up to 13 lessons. Your class supervisor will tell you what the format of your course will be.

The course uses a *time-line* approach. This is a logical line from thinking about boating and buying a boat through equipping it and using it safely and legally. The time-line should be clear from the course description given below.

Although the course is designed to be taught with the chapters in sequence, it is not mandatory. For a variety of reasons, flotillas may have to change the sequence. This is done because of local scheduling conflicts. The flotillas want to give you their best instructor for each subject. But that instructor may not be available on the night when the chapter would usually be taught. Thus, the schedule may be changed. You will probably not have a problem putting the pieces together to form the time-line.

The Course Content

Each chapter in this text has been written to help you achieve an important goal or goals. The **Student Study Guide** is designed to further these goals. In the appendix to the guide is a questionnaire. You can be helpful by using it to give the Auxiliary your reactions to our materials. Please take a few minutes of your time to complete it. Then *drop it in the mail.* It does not require postage. We want to know how you think we can improve the course.

Chapter 1 helps answer the question, ***"Which Boat Is for You?"*** For what kinds of uses are boats designed? How does this influence their types and construction? What do you need to know to select one for your particular purposes? What do you need to know to talk intelligently about a boat? How can you rate a boat before you buy it? What else should guide your purchase? The theme of the chapter is selecting a boat to fit your needs.

Chapter 2 deals with ***Equipment for Your Boat.*** In it you will learn what you must have on your boat to satisfy legal requirements. You will also learn what other equipment you should carry for your safety and convenience. And, you will learn how you can find out if your boat and its equipment meet safety and legal requirements.

Fig. Intro-5. Boaters Must Be Able To Rely On Their Equipment.

In **Chapter 3** we will discuss ***Trailering Your Boat.*** This chapter will give you information on how to get your boat safely and legally from your home to where you want to launch it. It will also help you know how to store it to protect it from the weather and from theft.

Chapter 4 is about handling your boat after you have it in the water. In ***Handling Your Boat,*** you will read about operating boats in general. What are some of the special circumstances you may meet? What can you do about them? What are some of the more serious safety problems? How can you prevent them?

Chapter 5 describes ***Your "Highway" Signs***. It will help you know about the aids to navigation provided by federal, state, and local authorities. Knowing about these aids will help you have a safe voyage. Knowing how to locate them on a chart will help you know where you are. These aids to navigation and the navigation rules in chapter 6 are important guides during your outings.

Chapter 6, *The Rules You Must Follow,* describes the Navigation Rules that govern the conduct of your vessel while it is on the water. These *traffic* rules help to prevent boat collisions. Knowledge of the rules will help you to have safe and enjoyable boating experiences.

Chapter 7 will help you learn about ***Piloting Your Boat.*** In it you will learn how to use a magnetic compass. You will also learn the importance of nautical charts and how they can help you boat safely. Too, you will learn what course to steer to get where you want to be and to return safely.

Fig. Intro-6. An Understanding of the Elements of Weather Forecasting is Important to Good Seamanship.

Fig. Intro-7. The Inland Waterways Make Recreational Boating Available to Millions.

Chapter 8 discusses ***Powering Your Boat.*** This non-technical presentation will help you to know more about how your boat is powered. Its primary focus is on what you need to know to maintain and to operate your boat's power plant properly.

In **Chapter 9** you will look at ***Lines and Knots for Your Boat*** and you will learn to tie some of the more important ones. The chapter centers on, "What do you need to know about handling ropes and lines and working with them to insure their proper use?" Like the rest of the book, the chapter seeks to help you to manage your boat safely.

Chapter 10 considers ***Weather and Boating.*** It provides answers to several questions: What do you need to know about weather to help you boat safely? How can you get accurate information about weather conditions? How can you recognize dangerous situations?

In **Chapter 11** you will learn about ***Your Boat's Radio.*** What are its purposes? How can you use it to aid you? What are its proper uses? What do you need to know to use it properly?

Chapter 12 deals with ***Inland Boating.*** It concentrates on questions such as: What special knowledge do you need to boat safely on rivers, lakes, and canals? What do you need to know to operate safely around dams? What procedures should you use in locks?

Chapter 13, *The Rest of Our Story*, considers a variety of problems such as: small boat safety, personal watercraft, hypothermia, conduct of motorboats near sailboats, retrieving an overboard person, and carbon monoxide poisoning.

We hope you find the course helpful and enjoyable. Your instructors, as well as the rest of the Auxiliary, wish you safe and pleasant boating.

1

Which Boat Is for You?

Boats come in many sizes and shapes for a variety of uses. They differ, too, in the materials used to make them. In fact, boats vary so much we should ask, "What is a boat?"

A boat or a vessel is anything used for transportation on the water. Huck Finn's raft was a vessel. A seaplane is a vessel when it is on the water. Canoes, kayaks, rowboats, and other small boats are vessels. Vessels range in size from small utility boats to large ships.

Boats come in such a large assortment because they serve many purposes. In this chapter you will learn about these purposes and how vessels are designed for them. You will also learn some simple facts about boat construction, materials, and uses.

BOATERS' LANGUAGE

Newcomers to any subject usually must learn a new vocabulary. Boating is no exception. The language of mariners has been developing for many centuries. It has utility and an exactness you need when talking about boats.

As we introduce terms, we will usually define them for you. You can also find some of them in the glossary appended to this book. If you do not find a word listed in the Glossary, look for its reference in the Index. The first time we use a technical term, we will print it in small capital letters and bold face print.

Origins of Boaters' Language

Boating has been around a long time, so its vocabulary has come from many places: ancient Greece, the Roman Empire, Scandinavia, England, and elsewhere.

Some boater's language is so common it has found its way into our everyday vocabulary. The term "blue Monday" came to us from England. The British Navy disciplined sailors on Mondays for infractions in the past week. The punishment consisted of lashes with a cat-o-nine tails or whip. No wonder Monday was blue. When not in use, the cat stayed in a sack. Of course, it was "out of the bag" when used.

Other language came from Norway. Most vessels are steered by **RUDDERS**. On an ancient sailing boat, the rudder was to the right of center on the rear or **STERN** of the vessel. Here it was protected from damage when the ship was in port. The **TILLER**, which turned the rudder, was kept under the **HELMSMAN**'s right arm.

In Norway, the rudder was a "stjorn" board or steering board. Stjorn, when pronounced sounds like "starn." So, the right side of a vessel when looking **FORWARD** became known as the stjorn board or **STARBOARD** side.

When a vessel came into port, it was with its left side next to the **WHARF**. This was the side most visible to the helmsman. It was also the side for the "load board." No wonder the left side of the vessel became known as the **LARBOARD** side. Larboard and starboard are more exact terms than left and right. They do not change if you are facing forward or **AFT**.

Because larboard and starboard sound somewhat alike, they are easily confused. Thus, larboard was changed to **PORT**. This was a logical choice as this is the side of the vessel next to the wharf when it is in port. Larger vessels load through **PORTS**, or openings, in their sides.

Remnants of ancient boats made of large, hollowed-out tree trunks or **KEELS** exist. These unstable vessels took on water easily. Although they didn't sink, they were of little value when slightly submerged in rough or icy water.

Planks were added later, and the trunk became but one part of the vessel. The name keel remained. The body of the vessel formed by the keel and the planks became known as the **HULL**.

The extreme aft portion of many boats is a flat, vertical surface extending from one side of the vessel to the other. This part of a boat became known as a **TRANSOM** from the Latin stem "trans" meaning across.

The **BOW** is the forwardmost area of a vessel. This term came from the Norwegian word "bov" meaning shoulder and pronounced "bow." You can almost see the shoulder of the boat pushing its way through the water.

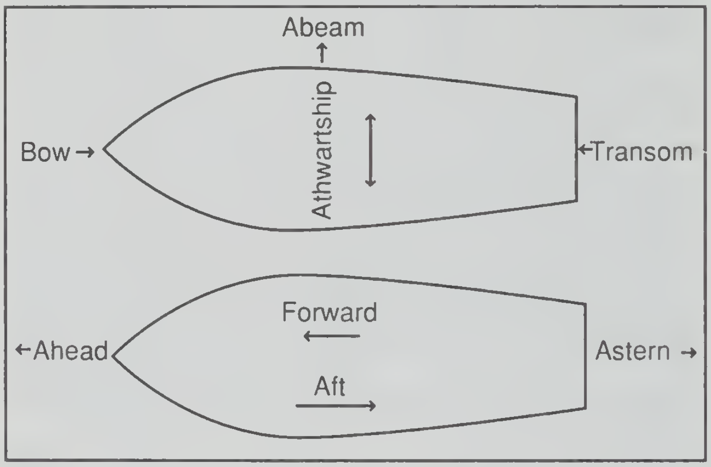


Fig. 1-1. Directions on a Boat

TYPES OF BOATS

Boats come in many models, sizes, and types. Each supposedly serves a specific need. A boat developed for one purpose may serve poorly for another. Likewise, a boat that is safe in one set of conditions may not be safe for others. When you select a boat, be sure that it will suit your needs. Also, be certain to operate it in appropriate sea and weather conditions.

Bass fishing boats, for example, help their owners get to good fishing holes quickly. These boats have sharply pointed bows and a minimal "V"-shaped hull forward. Their design permits them to operate safely at high speeds in sheltered water.

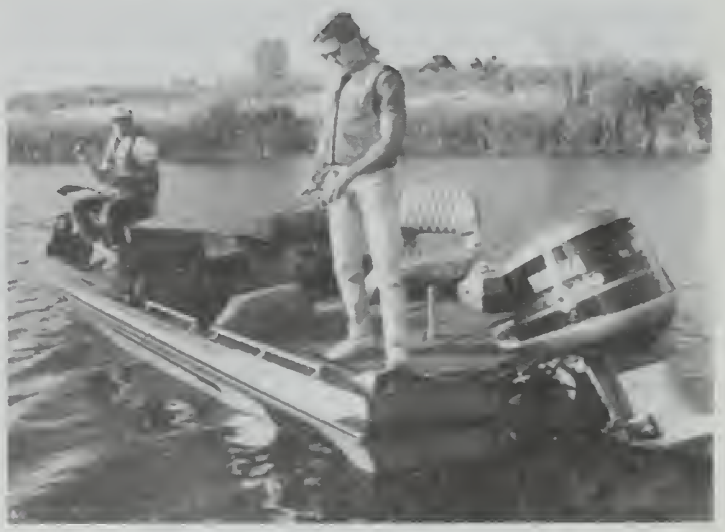


Fig. 1-2. A Bass Boat
(Courtesy of Yamaha)

A bass boat can be dangerous, though, when used in a tidal inlet, rough water, or the large swells of an open sea. One feature that makes it dangerous is its low **FREEBOARD**. Freeboard is the shortest vertical distance from the **GUNWALES**, or tops of the boat's sides, to the surface of the water. In many boats the least freeboard is at their transoms.

Another feature that may make some bass boats dangerous in inlets and other rough water is a foredeck, which sometimes slants downward towards the bow. The pointed bow may enter a wave and **SWAMP** the boat. This is not to say that a bass boat is unsafe. That would not be true. What it says is, "Operate your boat only under its design conditions."

HYDROPLANES are well designed boats (see fig. 1-7). Even so, they may be unsafe under certain conditions. These racing vessels are made to skim over the water's surface. At rest, they have little freeboard and this may be further reduced if they are powered by large **OUTBOARD MOTORS**. They are designed for use in

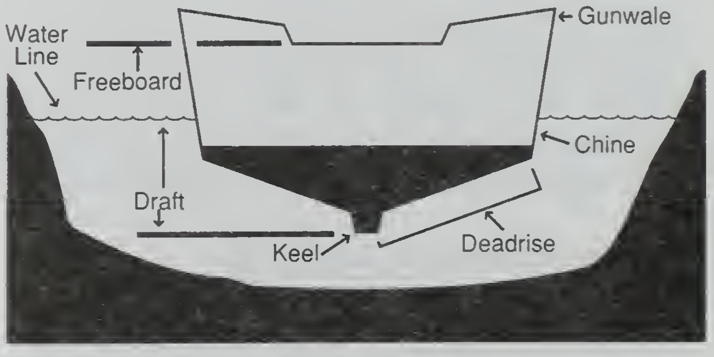


Fig. 1-3. Some Terms Used to Describe a Boat

smooth water. But the water may not be smooth at race time. In recreational use, the water may be calm going out and choppy when returning.

Let's suppose you are in your hydroplane and there is a strong wind and a choppy sea. Now suppose that your boat is **DEAD IN THE WATER** or **ADRIFT**. This means that it is not under power and not **MOORED, ANCHORED**, or **AGROUND**. Like other boats with higher bows than sterns, it turns its bow away from the wind. This means that the stern, with little freeboard, turns toward the waves. When it does, the water may roll over the transom and swamp it. There is nothing wrong with the boat. It was not made for such conditions.

Select your boat to suit your needs. Use it only under the conditions for which it was designed! It always pays to check the weather before you go out and while you are on the water. You can get continuous weather information on your VHF-FM radio.

OUTBOARD MOTORS AND STERN DRIVES

Most small pleasure boats have outboard motors or **STERN DRIVES**. Stern drives were formerly called **INBOARD/OUTBOARDS** or I/Os. An outboard motor bolts or clamps to the transom. A stern drive has an engine within the hull of the boat. This engine is connected to a drive unit through a system of gears. The drive unit is also called the **LOWER UNIT** or **OUTDRIVE.** This unit is much like the lower portion of an outboard motor and is attached to the boat's transom. The boat steers by turning the outboard motor or the lower unit in one direction or the other.

Fig. 1-4. Outboards Remain Extremely Popular with Recreational Boaters. (Courtesy of Scout Boats and Honda Marine)

Both outboards and stern drives have advantages. Outboards are easy to service or replace. They take up less space inside the boat. And they are lighter than stern drives of the same horsepower. A 150-horsepower outboard weighs about 300-400 pounds. A stern drive of 140-170 horsepower weighs about twice as much. Stern drives, however, are quieter and more economical in their fuel use.

Stern drive engines have longer lives than outboards. Outboard motors may turn more than 5,000 revolutions per minute (rpm) to develop their maximum horsepower. Stern drives usually develop maximum horsepower at less than 4,000 rpm. Thus, a stern drive engine does not work as hard to develop its maximum horsepower.

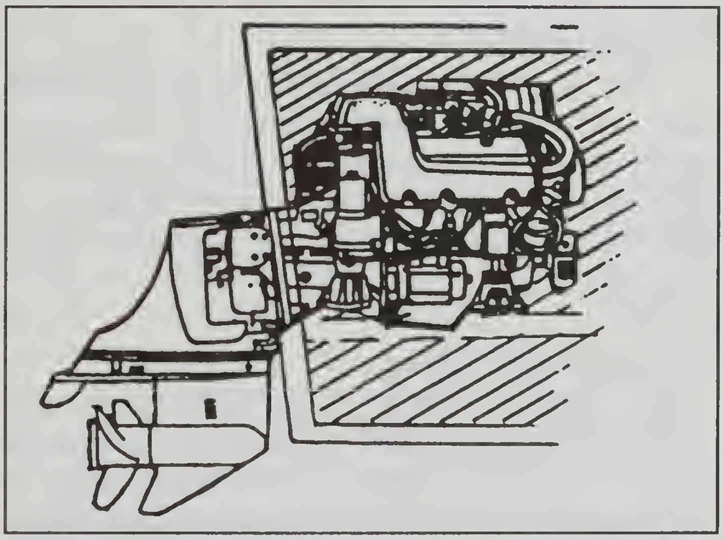


Fig. 1-5. A Stern Drive Power Plant

In the water, and especially in rough weather, it is easier to work on a stern drive engine than an outboard—it's in the boat and not behind the transom.

The transom on a boat with an outboard motor usually has a large section cut away (see fig. 1-3). This is done so that the lower part of the motor will be at the correct level for best performance. A cutaway transom lowers the boat's freeboard. To keep boats with transom-mounted outboards from swamping, many have wells into which their motors tilt when raised. The forward walls of these wells are raised to keep water from entering the boat. A well takes up deck space, but the lack of a well can be dangerous.

You can overcome the disadvantage of a cutaway transom by attaching an outboard motor to a mount or bracket on the transom. With a bracket you can have a full transom and still tilt your motor. When mounted this way, an outboard will make less noise in the boat. Too, it will occupy less deck space than if it were mounted on the transom since a well is not necessary. The full transom is safer for small children.

There are three important disadvantages of a stern drive. The first is the loss of deck space. The engine, mounted within the hull near the stern, has a large hood over it. Second, the gears connecting the engine to the lower unit may be a source of problems. And third, any engine mounted within a boat's hull presents dangers from fire and explosion.

HULL DESIGN

One way to classify boats is by how they ride in the water. **DISPLACEMENT-HULL** boats move through the water and push it aside or displace it. **PLANING** boats move faster and, after gaining speed, ride more nearly on top of the water.

Displacement Hulls

All boats at rest or moving slowly are displacement boats. Each displaces a volume of water equal in weight to its own weight. A displacement-hull vessel always displaces a volume of water equal to its weight, regardless of its speed. If the weight of the boat exceeds the weight of the water displaced, it sinks.

At slow speeds, it is easy for a displacement-hull boat to push the water aside, forming a **BOW WAVE.** As speed increases, the bow wave becomes higher and the boat tries to climb it. But the boat is not designed to do this so there is a practical limit to its speed. The longer the waterline a displacement vessel has, the faster it can move if it has the power to do so.

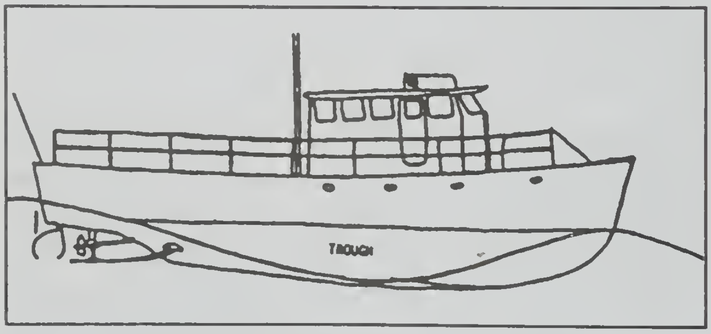


Fig. 1-6. Displacement Vessels Move Through the Water.

The top speed of a displacement vessel depends on its length and hull design. This is what makes the design of sailing vessels in America's Cup races so important. The rules say how long the vessel can be. But different hull designs permit different speeds. The top speed for most small displacement hull boats is about 7 - 8 knots or about 8 - 9 miles per hour.

Despite their slow speed, displacement hull vessels have advantages and special uses. They are steady and comfortable and can handle rougher water than planing boats. They are more economical to operate and lend themselves to cruising and living aboard.

Planing Hulls

Planing hull boats climb their bow waves and ride on top of the water. When a planing hull boat is moving slowly, it is a displacement vessel. It becomes a planing vessel at higher speeds. "On plane," it uses most of its power to move forward instead of pushing the water aside. When on plane, it displaces a volume of water less than its own weight.

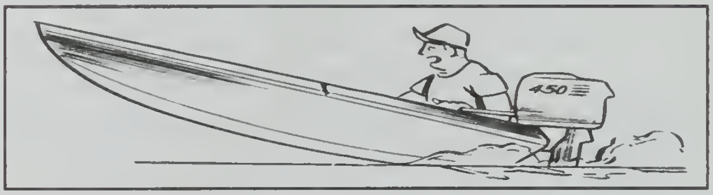


Fig. 1-7. A Hydroplane is an Extreme Form of a Planing Hull. It Moves on Top of the Water.

There are many types of planing hulls. Most have extensive flat surfaces, angled to form "V"-shaped hulls. The more horizontal the surfaces, the flatter is the bottom of the boat and the harder the ride in choppy or rough water. Flat-bottom boats usually are more stable than round or "V"-shaped boat hulls.

Semi-Displacement Hulls

Some hulls have both displacement and planing features. Up to a certain power and speed they displace the water. Beyond this point, their hulls rise to a partial plane. They never rise as far up in the water, though, as planing hulls.

Increasing the power of a semi-displacement hull vessel increases its speed. It never gets "on top" like a planing hull, however. Most **TRAWLERS** and many **CRUISERS** fit into this group. Many sailboats up to about 19 feet in length have semi-displacement hulls.

There is no single, all-purpose, perfect hull design. Each design is a compromise, and you must make a choice based on your boat's projected use.

Sailboats

Sailboats are discussed in chapter 13, The Rest of Our Story.

USES OF BOATS

A common way to classify power boats is by their uses. Power boats include **UTILITY BOATS**, **RUNABOUTS**, **CRUISERS**, **PONTOON BOATS**, **HOUSEBOATS**, and **PERSONAL WATERCRAFT**.

Utility Boats

Utility boats include **PRAMS** and **DINGHIES**, **INFLATABLES**, **SKIFFS**, and **UTILITY OUTBOARDS**.

Prams and dinghies

Prams and dinghies are among the smallest of the utility boats. Both serve as **TENDERS** for larger craft. As such, they transport people, gear, and supplies to and from the larger craft. They are about eight to 10 feet long and have wide **BEAMS,** or widths, relative to their lengths. They usually have oars for rowing, but they may have small outboard motors. On cruises, they are either towed behind a larger boat or carried aboard.

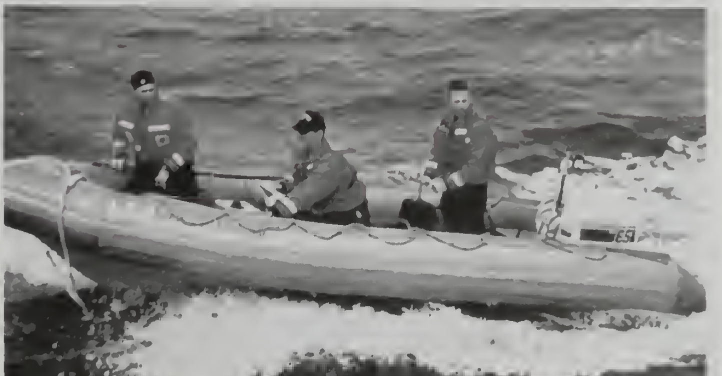


Fig. 1-8. A Coast Guard Rigid Hull Inflatable Vessel

Inflatables

Inflatables are used as dinghies and as sport boats. They are extremely stable and can carry significantly larger loads than comparably sized rigid boats. They are usually so buoyant that they will stay afloat even when filled with water. As dinghies, they may be towed astern, hoisted on **DAVITS**, stored on deck, or deflated and stored in a locker.

Generally, inflatables used as sport boats have hard transoms to which outboard motors may be attached. Some also have rigid **FIBERGLASS** hulls with inflated tubes. These tubes are attached to the sides of the boat above the waterline. Inflatables with rigid hulls plane and steer easier than inflatables with non-rigid hulls. Although heavier than other inflatables, rigid hull inflatables weigh considerably less than all-fiberglass boats of the same size. This is an advantage in transporting them. On the other hand, rigid inflatables are less stable than other inflatables because of their rounded bottoms.

Skiffs

A skiff is a flat-bottomed utility boat with either straight or slightly flared sides. One form of skiff is a **JON BOAT**; a long, narrow boat with a flat bottom. It may be as short as 10 feet or as long as 16 feet. A jon boat has the same width from bow to stern except that the bow may be slightly narrower. Also, the flat bottom turns up slightly near the bow end. A homemade jon boat is most often made of wood. Commercially built ones are usually made of aluminum.

Although skiffs are easy to row, many have small outboard motors. If a skiff has a wide beam, it is stable and ideal for hunting or fishing in *sheltered water*.

Utility Outboards

Utility outboards are small boats, much like "rowboats." They have outboard motors and are sometimes difficult to row.

Some utility outboards have small decked-over areas in their bows but most are completely open. Most frequently they are 12 to 14 feet long. They can operate in choppier water than skiffs because of their pointed bows. The

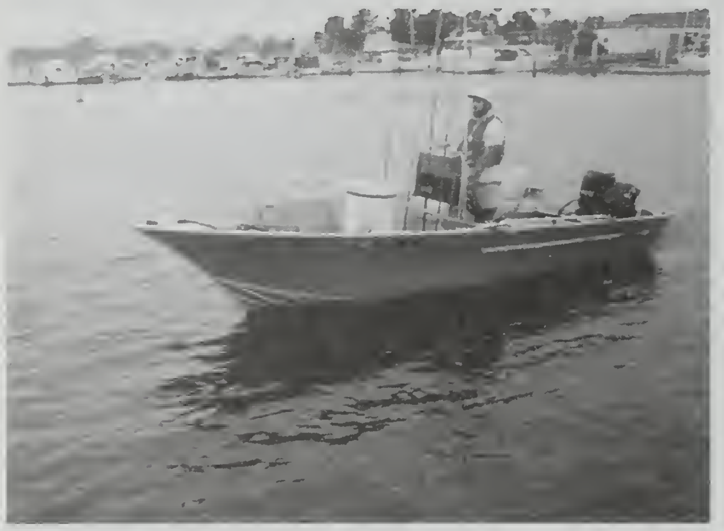


Fig. 1-9. An Open Fisherman

Fig. 1-10. Runabouts Are Useful for a Variety of Activities on the Water.

amount of "chop" in which they are safe depends on their freeboard and load. They are popular as fishing boats and should be used in sheltered water.

Runabouts

Runabouts are small, sporty craft used for day cruising, water skiing, and fishing. They may be completely open or have decked-over bows. The roughness of the water in which they can operate depends on their freeboard and the weights of their loads.

Runabouts range from highly polished sports craft with cushioned seats to boats designed primarily for fishing. The principal uses of the more polished craft are day cruising and ski towing.

Bowriders

One type of runabout has a split dashboard and windshield which gives ready access to the forward part of the boat. This is called a "**WALK-THROUGH**" windshield. Usually, the forward area has padded seats that can be used while the vessel is underway. This type of boat is sometimes called a **BOWRIDER**.

A bowrider boat should not be confused with the act of **BOWRIDING**. In bowriding, passengers sit on the raised, forward deck of the vessel. They may or may not have their legs draped over the side. They may or may not be straddling a **STANCHION;** an upright post that supports the **BOW RAIL.**

Bowriding is a dangerous activity. Rails can give way or a person can fall overboard because of an unexpected wave, wake, or sudden turn. When docking, legs can be crushed against pilings. The result of bowriding may be traumatic and a fall overboard can be fatal. It is difficult to escape the boat's **PROPELLER** if you fall overboard. Bowriding is illegal in most states and in all federal parks and waters.

Cathederal Hull

Another type of runabout has a **CATHEDRAL HULL.** This hull is shaped into a small "V" in the middle and has smaller "Vs" on each side. It is a very stable boat. In rough or choppy water, though, it gives a hard ride.

Open Fisherman

Less sporty runabouts are used primarily for fishing and may be one of two types. The first type is an **OPEN FISHERMAN**.

An open fisherman has no raised decks. It has a **CONSOLE**, most often in the center of the boat. Thus, it is a **CENTER CONSOLE** boat. The console holds the **HELM** or steering wheel, the boat's instruments, and the gearshifting mechanism.

Center console boats make excellent fishing boats. They are usually powered by outboard motors. Some have dual outboard installations. They often have at least one disadvantage--their shallow depths from gunwale to deck. People who fish, frequently stand on the deck and lean their legs against the gunwale for support. The shallow depth makes it difficult for them to keep their balance. Many other small boats have this disadvantage.

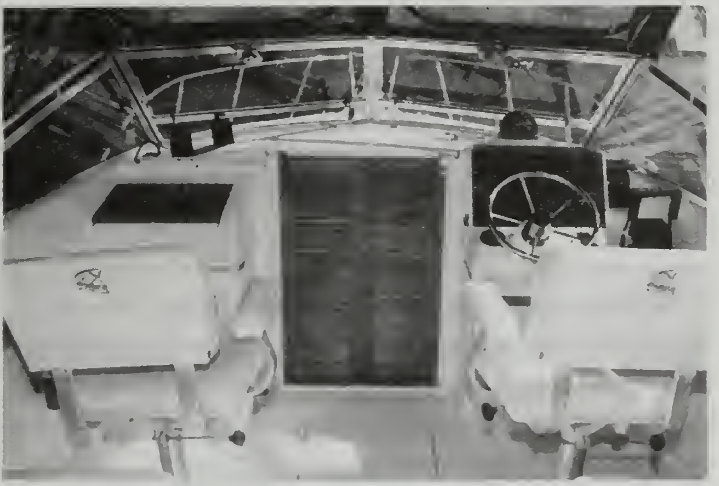


Fig. 1-11. A Cuddy Cabin Boat

Cuddy Cabin

Another type of fishing boat has a **CUDDY CABIN,** a small cabin for overnight cruises. It is seldom used for this purpose, though. The cabin is small, and you can't keep insects out of it. The boat usually lacks sanitary and cooking facilities although portable **HEADS** or toilets may be added. A cuddy cabin does have advantages. It serves as dry storage space and provides some security for equipment left aboard.

It is often difficult to go forward around a cuddy cabin. To anchor a boat with a small cabin, you usually must enter the cabin and crawl up through a **HATCH** to reach the forward deck. The "novelty" of this wears off quickly, especially if you are bottom fishing and often changing from one spot to another.

In some boats, this disadvantage is overcome by "walk-around" cuddy cabins. Space is taken from the upper areas of the cabin and used for walkways on each side of the vessel. In addition to ease of anchoring, this arrangement usually provides a seat forward on which it is legal to ride.

Fig. 1-12. Cruisers Have More Room for Longer Trips.

Cruisers

Large runabouts with cuddy cabins are like small cruisers. Strictly speaking, though, cruisers are motorboats with cabins, **GALLEYS** (cooking facilities), plumbing, and other arrangements necessary for living aboard.

Cruisers come in many shapes and sizes. They vary from small overnight vessels to boats for extended voyages and living aboard. Cruisers, in general, are more **SEAWORTHY** than runabouts. In the past, most cruisers were displacement craft. Today, most are planing or semi-displacement craft, powered by single or dual engine installations. Small cruisers may use outboards or stern drives, but larger ones usually have inboards.

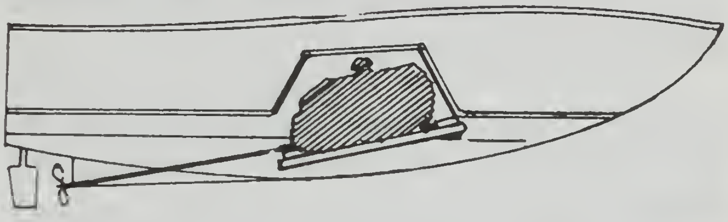


Fig. 1-13. A Single Inboard Engine Installation

INBOARD ENGINES are similar to stern drives but they are mounted below the deck and are farther forward. They have straight propeller shafts. A shaft connects the engine to the propeller.

Pontoon Boats

Pontoon boats have found considerable popularity in *sheltered* waters. In their simplest form, they are platforms mounted on two or more cylindrical floats. These boats are often very elaborate.

Most pontoon boats have outboard motors but stern drives are common on larger ones. They have shallow **DRAFTS**, which means they do not require much water in which to operate.

Pontoon boats are popular on rivers and small, inland lakes. They are used as fishing boats, cruisers, work platforms, and party boats.

Pontoon boats tend to be unstable and are not suitable for use in rough water. Use them with extreme caution in exposed waters, and do not expose them to severe weather conditions. Pontoon boats with covered tops may blow over in windy weather. Do not use them in gusty weather or on large bodies of water.

Fig. 1-14. A Houseboat Is Like a Floating Summer Home.

Houseboats

A houseboat is a variation of a cruiser. It offers most of the conveniences of home, including hot and cold running water.

A houseboat usually has one or two stern drive or inboard engines. Some have enough speed and power to plane and to tow water skiers.

Houseboats give their owners a lot of space, but at some cost. Seakeeping ability is sacrificed for livability. They are limited to relatively sheltered waters because of their hull designs, low freeboards, and large windows. Large windows are dangerous in rough water.

Personal Watercraft

Personal watercraft are highly maneuverable, power-driven vessels that can operate in very shallow water. They can carry up to three riders. Most people know them by the name "**JET SKI**," a registered trade name. They are more correctly called **PWC**s and are planing vessels. See chapter 13 for more on PWCs.

OTHER POWER PLANTS

We have touched briefly on outboards, stern drives, and inboard engines. There are two additional types we should mention.

A personal watercraft has a **JET DRIVE**; a pump that jets water out to serve as a propellant. The advantages of jet drives are fast acceleration and safety. Propellers on conventional-drive boats often turn slowly even when their gears are in neutral. An exposed propeller can cause serious injury. PWCs overturn easily but stop or circle back to their riders. Their jet drives do not present safety hazards that propellers do.

Jet drives are used in shallow, rock-strewn water where propellers are easily damaged. Sight-seeing boats in the Hell's Canyon area of the Snake River use jet drives. You must still use caution around rocks even if you have a jet engine. Rocks can puncture your boat's hull.

Although PWCs can operate in shallow, muddy or sandy water, other jet-propelled boats should not. The difference is in the size of their engines. The engines of runabouts and cruisers equipped with jet drives pump large quantities of water. The mud or sand that is pumped with the water quickly damages parts in their pumps and propelling mechanisms.

The second drive is a "**TUNNEL DRIVE**." It is a variation of an inboard or direct-drive engine. The propeller and part of the drive shaft are in a tunnel, a trough in the bottom of the boat.

The tunnel acts as a shroud to protect the propeller and increase its efficiency. It also provides a more favorable thrust angle for the propeller and a better angle of attachment of the drive shaft to the engine.

MATERIALS FOR CONSTRUCTING BOATS

Boat designers use a large variety of materials. The first boats were wooden ones. Today, boat builders use wood, fiberglass, aluminum, steel, and combinations of these materials.

Steel-Hulled Vessels

Steel is an ideal material for making boats. Unfortunately, steel-hulled boats under 30 to 35 feet long are too heavy for economical operation. When speed can be sacrificed for strength, steel is an excellent building material.

Aluminum-Hulled Vessels

Aluminum boats are common. Their hulls are lightweight. They cost less than hulls made of other materials, and they can take the hard knocks canoes and fishing boats get. Canoes, skiffs, jon boats, runabouts, and small cruisers, among others, use aluminum. Aluminum has the disadvantage of being noisy; all sea noises are heard through the hull. Noises inside the hull are transmitted to the water—an important consideration for those who are fishing. Aluminum is also a good transmitter of heat, so hulls made of it tend to sweat considerably.

Aluminum also has the disadvantage of being easily corroded by **ELECTROLYSIS.** This is not a disadvantage for canoes and skiffs used in fresh water and stored on land. It is a serious consideration, though, for boats moored in salt water.

Boats moored in salt water usually have their bottoms painted with **ANTI-FOULING PAINTS** to reduce plant and animal growth. Most of these paints contain copper. In salt water, copper and aluminum set up an electrolytic action and the aluminum quickly corrodes.

Tin-based anti-fouling paints, which do not interact as readily with aluminum, were once used on aluminum hulls. The Environmental Protection Agency has determined, however, that the tin is poisonous to marine life, so it is banned. Small quantities are available for painting outdrives and mounting brackets.

There are presently two alternatives for protecting aluminum. One is to use a layer of non-metallic paint between the hull and the anti-fouling bottom paint. This works fine unless a scratch exposes the aluminum hull. The other alternative is to use a polymer, anti-fouling paint. This paint is expensive and very difficult to apply.

Wooden Hulled Vessels

Wood, once the choice of small boat builders, is used much less frequently today. This is not because wood is an undesirable construction material. There are many people who would not trade a wooden boat for any other one. Wood is attractive, and if properly maintained, lasts a long time. Good wood for boat construction is expensive.

Wood demands considerable attention. Owners of wooden boats spend many hours each year getting them ready for launching. Wood needs scraping and repainting annually. The seams of wooden boats need periodic **CAULKING** to make them watertight.

Fiberglass Construction

For many people, fiberglass is the boatbuilding material of choice. Fiberglass boats account, in large part, for the rapidly growing popularity of recreational boating. The material is relatively inexpensive and can easily be formed into complex shapes. Thus, it permits the use of designs that are difficult to make with wood. Furthermore, it is easily repaired when damaged. Most importantly for the average boat owner, fiberglass is easily maintained.

Fiberglass, or more properly, glass-reinforced resin, has its disadvantages. It is heavy. Fiberglass with the strength of steel weighs more than steel. Although the glass will not burn, the resins that bind it together will.

Most fiberglass boats have some wood parts. Longitudinal **STRINGERS** (see fig. 1-15) are usually made of wood. Stringers strengthen the hull. Additionally, most transoms contain wood for reinforcement.

Hand-Layup Process

A fiberglass boat is built from the outside in (fig. 1-15). First, a plug is made and from this a female mold is formed.

The gel coat is applied to the inside of the female mold. It gives the vessel its color and finished surface. In the **HAND-LAYUP PROCESS,** a layer of fiberglass is laid down on the gel coat. It is then bonded to it with resin on what will be the inside of the gel coat.

After this, other fiberglass layers are added until the desired thickness of the hull is reached. The strength and durability of the hull depend on how the fiberglass materials are combined. They also depend on the number of fiberglass layers.

After the basic fiberglass hull is made, it is strengthened with stiffeners, stringers, and other members. Then decks, cabins, and superstructure are added.

Chopped-Strand Process

A second method of fiberglass construction is the **CHOPPED-STRAND PROCESS.** In it, a gun fed with resin and fiberglass strands sprays the inside of the gel coat. In one operation, the gun chops the strands and mixes them with resin. The chopped strands are not as strong as the longer fibers of the fiberglass cloth and mats used in the hand-laid process.

Handling the gun requires skill. Any miscalculation causes the hull to be thick in some places and thin in others. Thin places make a weak boat. Thus, the quality of workmanship is important.

Matched-Die Process

A third method is the **MATCHED-DIE PROCESS.** Matched dies are male and female molds, usually made of metal. These are clamped together with a laminate between them. By applying the correct amount of pressure and heat, the hull is made uniform throughout.

Sandwich Construction

The fourth method is **SANDWICH CONSTRUCTION.** In it, core material, usually balsa wood, is sandwiched on either side by layers of fiberglass impregnated with resin. Other core materials are sometimes used, such as formed plastic or plywood. Sandwich construction provides a boat that is strong and buoyant. As with any other fiberglass boat with wood construction, should leaks develop in the fiberglass and water reach the wood, rot will occur.

General Considerations

Fiberglass boats are strong. This is true even if they have little framing. This is not to say there are no weak fiberglass boats. The engineering and workmanship that goes into any boat will affect its strength. One well-known boat manufacturer tried to "cut corners" recently by removing some of the stringers used to give strength. As a result, many of these boats proved unseaworthy and cracked. Other things being equal, a hand-laid boat is stronger than a chopped and blown one.

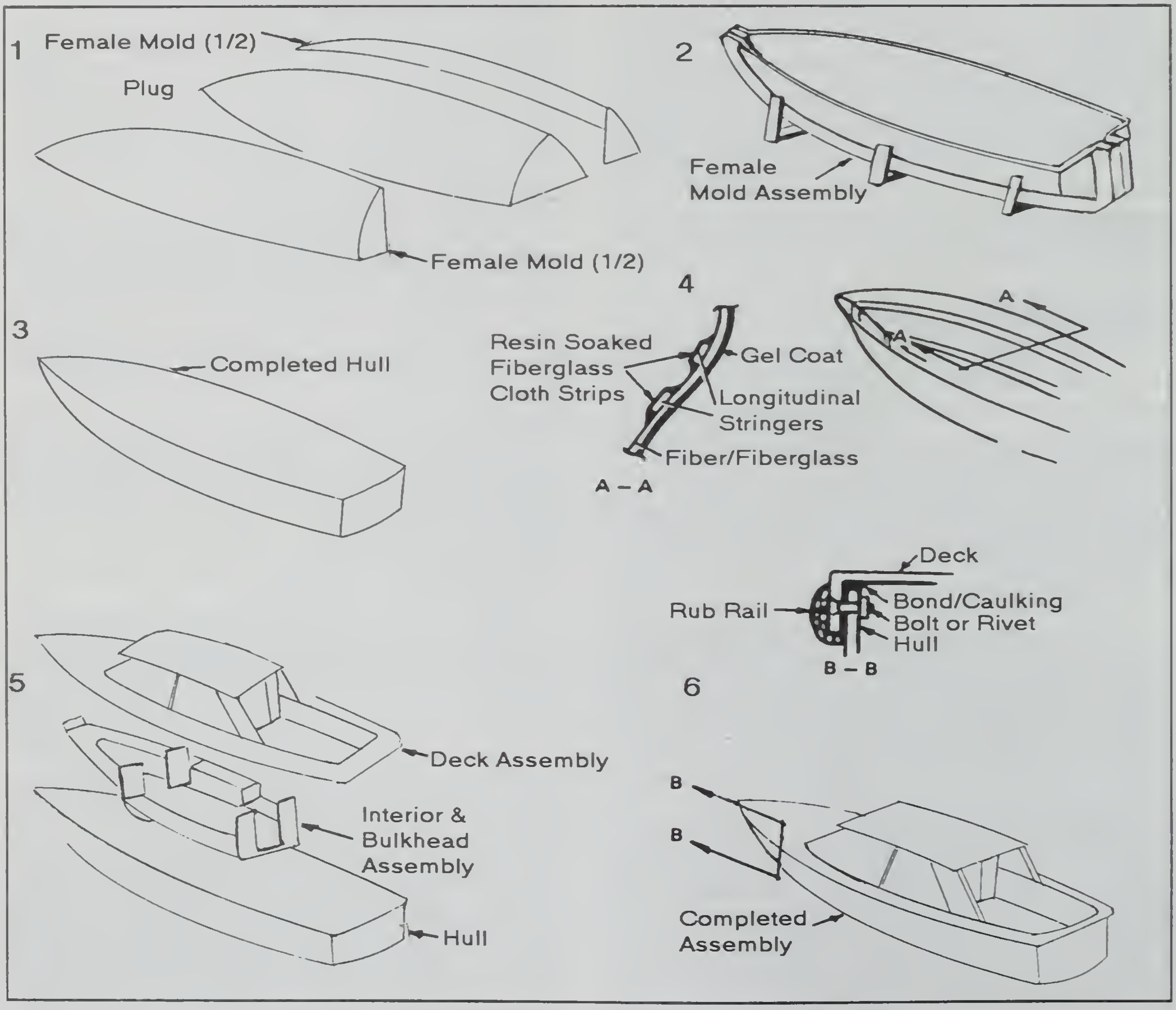


Fig. 1-15. Typical Fiberglass Construction Techniques

Fiberglass Disadvantages

Fiberglass is heavier than water. A fiberglass boat filled with water will sink unless it has built-in flotation. Styrofoam most often provides the flotation. Most boats less than 20 feet long have additional flotation.

A serious disadvantage of fiberglass boats is the ease of covering up shoddy workmanship. Air bubbles in fiberglass laminates weaken the hull. Yet they are almost impossible to see. There are so many layers in fiberglass hulls that air bubbles in the innermost layers are undetectable. When complete, it is impossible to inspect most fiberglass hulls, as they are covered by decks and other structures. Chopped-strand hulls may have uneven thickness, yet you can't tell it.

Another disadvantage of a fiberglass boat, especially if it is to be trailered, is its weight. In fiberglass, strength and weight are related. Strong fiberglass boats are usually heavy. Light ones may or may not be as strong. Although not exact, a rule of thumb is that a well-constructed, hand-laid fiberglass hull weighs about 100 pounds per foot. The specifications on your boat should tell you if it comes close to this. You can expect a hand-laid boat to cost considerably more than a chopped and blown one. The difference is in the amount of materials and labor.

Glitzy boats selling at bargain prices are often chopped and blown. If hand-laid, they may have few layers. They may look great but they often have plywood decks and other exposed wooden members that can rot. Lift the carpet on the boat you are considering. What is used to make its deck?

You can find out more about the boat you wish to buy by reading the literature published by its manufacturer. How complete is the information? Reliable manufacturers want you to know what you are buying. If you can visit the manufacturing plant, arrange for a tour. Most factories will be glad to show you boats in various stages of construction.

YOUR INTENDED USE

One guideline in selecting a boat is how you will use it. Make certain that the boat you intend to buy matches your intended use. People tend to look at boating in one of two ways. Some owners take pleasure in knowing that their boats are built for heavy seas. Others get their enjoyment from the rush of adrenaline they get from pushing their boats to their limits.

Not all boats are designed for the rigors they will endure. Hull failures are common on planing boats driven by would-be ocean racers. Most hulls are not designed for jumping wakes and waves and lunging off swells.

Displacement and semi-displacement hulls can also be overstressed. For example, a houseboat used on the ocean is subjected to stresses for which it was not designed. Even a well-constructed boat hull can be damaged by use in adverse sea conditions.

THE COAST GUARD CUSTOMER INFOLINE

If you are planning to buy a new or used boat or engine call the Coast Guard Customer Infoline at 1-800-368-5647. In the Washington, D.C. area, call the Infoline at 202-267-0780. You can get information about possible safety defects and recalls, Coast Guard boarding policy, documentation or registration of recreational boats, and dozens of other subjects. You can call to comment on a Coast Guard Boarding of your boat or to report possible safety defects such as hull cracks and engine defects.

This service, operated by the United States Coast Guard, is available from 8:00 a.m. to 4:00 p.m., Eastern time, Monday through Friday except on federal holidays. Recorded messages will give you information on several subjects or Customer Service Representatives (CSR) will provide live answers. If your question is very technical, the CSR may transfer your call to a subject matter specialist or have the Coast Guard specialist call you back. On some subjects, the CSR may be able to send you written information or refer you to another source.

The Infoline maintains a telephone service for the hearing impaired (TDD). Through the use of their own TDD, hearing impaired people can use a typewriter-like TDD device to call a telephone equipped with a similar device at the receiving end. The Infoline toll free TDD numbers are 1-800-689-0816 and in the Washington area 202-267-6707. These numbers connect your TDD with an Infoline Customer Service Representative.

The Coast Guard also maintains a Navigation Information Services Computer Bulletin Board. By this means, a wide range of safety information is now available to anyone with a personal computer and a modem. Boaters can learn about current manufacturer boat recalls, how to get a free courtesy marine examination, where to find a boating safety class, how to get a copy of the latest *Boating Statistics*, and much more. The Bulletin Board Service is in operation 24 hours each day. The modem number is 703-313-5910.

MARINE SURVEYORS

Marine surveyors make boats their specialty. If you are planning to buy a used boat or engine, it is a good idea to hire a surveyor. The surveyor will assess the boat's condition and tell you what it needs to bring it to good working condition. They often work with insurance companies, for example, to assess accidental damage.

BUYING A BOAT

When you are buying a boat, there is no substitute for a written sales agreement. It should clearly state your intent and that of the seller. Thus, it should prevent unpleasant surprises.

Your boat sales contract should state price, delivery date, and method of payment. It should include, among other things, an inventory of the boat's equipment. A detailed description of the condition of the boat and its equipment is essential. If you make a refundable deposit, that fact should be clear. Any limitations on a refund should also be stated. If a loan is involved, the contract should state whether the sale is subject to the availability of the loan.

The contract should also stipulate that the sale is subject to a satisfactory marine survey. As a buyer, you should take a sea trial, but have the survey done on land. Problems noted during the trial run and the survey should be addressed in the contract. If the boat is not being sold "as is," the contract should say so. If the seller is responsible for correcting problems or defects, it should be clearly stated. The contract should state, too, the time limit for making corrections. The length of time for discovering and correcting new problems after the purchase date should also be included.

Even if you are having the boat surveyed, you should ask probing questions. Ask about its prior use, its maintenance record, and its history of problems. Has it had any blistering? Has it had accidental damage? What is its present condition? The seller should be completely honest, but again beware!

Finally, you should make certain that you have all of the boat's papers. You will need them for state **REGISTRATION** or for new **DOCUMENTATION** with the Coast Guard. As a buyer, you should realize that you do not have any rights under the seller's insurance. Arrange to have your own insurance in place at the closing date.

You're Invited!

As a boat owner you've shown responsibility by taking this course. Now consider furthering your boating knowledge and safety on the water by joining the U.S.C.G. Auxiliary, a voluntary civilian component of the U.S. Coast Guard.

The Auxiliary Provides Education in *Weather, Communications, Piloting, Boat Handling, Navigation, and many other subjects*.... including all unclassified courses of the Coast Guard Institute. As a member of the Auxiliary, there are no tuition fees for any Coast Guard or Auxiliary course.

Contact your instructor for information on how to join the U.S. Coast Guard Auxiliary.

2

Equipment For Your Boat

In 1971 Congress ordered the U.S. Coast Guard to improve recreational boating safety. In response, the Coast Guard drew up a set of regulations.

Beside these federal regulations, there are state and local laws you must follow. These sometimes exceed the Coast Guard requirements. This chapter discusses only the federal laws. State and local laws will be discussed by your instructors. As with other laws, "Ignorance of the boating laws is no excuse."

The rules fall into two groups. These include regulations for your boat and regulations for equipment on your boat.

REQUIREMENTS FOR YOUR BOAT

Most power boats on waters within federal jurisdiction must be registered or documented. These waters are those that provide a means of transportation between two or more states or to the sea. They also include the territorial waters of the United States.

Documenting of Vessels

A vessel of five or more net tons may be **DOCUMENTED** as a yacht. In this process, papers are issued by the U.S. Coast Guard as they are for large ships. Documentation is a form of national registration. The boat must be used solely for pleasure. Its owner must be a U.S. citizen, a partnership of U.S. citizens, or a corporation controlled by U.S. citizens. The captain and other officers must also be U.S. citizens. The crew need not be.

If you document your yacht, you have the legal authority to fly the yacht ensign. You also may record bills of sale, mortgages, and other papers of title with federal authorities. Doing so gives legal notice that such instruments exist. Documentation also permits preferred status for mortgages. This gives you additional security and aids financing and transfer of title. You must carry the original documentation papers aboard your vessel. Copies will not suffice.

Registration of Boats

If your motorboat is not documented, registration in the state of its principal use is probably required. If you use it mainly on an ocean, a gulf, or other similar water, register it in the state where you moor it.

If you use your boat *solely* for racing, it *may* be exempt from the requirement in your state. States may also exclude dinghies. Some require registration of documented vessels and non-power driven boats. A temporary certificate of number is good for 60 days from the date of issue. During this time you do not have to display a registration number.

All states, except Alaska, register boats. In Alaska, the U.S. Coast Guard issues the registration numbers. If you move your vessel to a new state of principal use, a valid registration certificate is good for 60 days.

You must have the registration certificate (certificate of number) aboard your vessel when it is in use. A copy will not suffice. You may

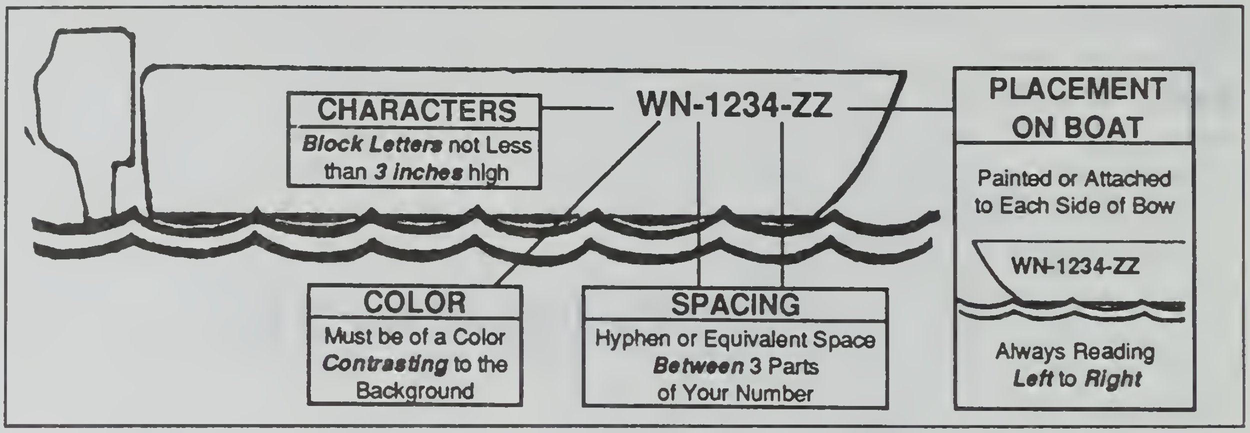

CHARACTERS
Block Letters not Less than 3 inches high
WN-1234-ZZ
PLACEMENT ON BOAT
Painted or Attached to Each Side of Bow
WN-1234-ZZ
Always Reading Left to Right
COLOR
Must be of a Color Contrasting to the Background
SPACING
Hyphen or Equivalent Space Between 3 Parts of Your Number

Fig. 2-1. Proper Number Placement

be cited if you do not have the original on board.

Numbering of Vessels

A registration number is on your registration certificate. It is in a sequence of two letters, up to four numerals, and one or two letters. The first two letters are the code for the state of registration. You must paint or permanently attach this number to both sides of the forward half of your boat. Do not display any other number there (fig. 2-1).

The registration number must be clearly visible. It must not be placed on the obscured underside of a flared bow. If you can't place the number on the bow, place it on the forward half of the hull. If that doesn't work, put it on the superstructure. Put the number for an inflatable boat on a bracket or fixture. Then, firmly attach it to the forward half of the boat.

The letters and numbers must be plain ***block*** characters and must read from left to right. Use a space or a hyphen to separate the prefix and suffix letters from the numerals. The color of the characters must contrast with that of the background and they must be at least three inches high.

In some states your registration is good for only one year. In others, it is good for as long as three years. Renew your registration before it expires. At that time you will receive a new decal or decals. Place them as required by state law. You should remove old decals before putting on the new ones. Some states require that you show only the current decal or decals. If your vessel is moored, it must have a current decal even if it is not in use.

If your vessel is lost, destroyed, abandoned, stolen, or transferred, you must inform the issuing authority. If you lose your certificate of number or your address changes, notify the issuing authority as soon as possible.

Sales and Transfers

Your registration number is not transferable to another boat. The number stays with the boat unless its state of principal use is changed.

Hull Identification Number

A **HULL IDENTIFICATION NUMBER** (HIN) is like the Vehicle Identification Number (VIN) on your car. Boats built between November 1, 1972 and July 31, 1984 have HINs such as those shown in figure 2-2a. The letter "M" in figure 2-2a means the optional method for showing the date of certification was used. The last four characters show the model year and month when construction started. In the figure, the "73" means 1973. Model years began in August which is an "A." "E" means December.

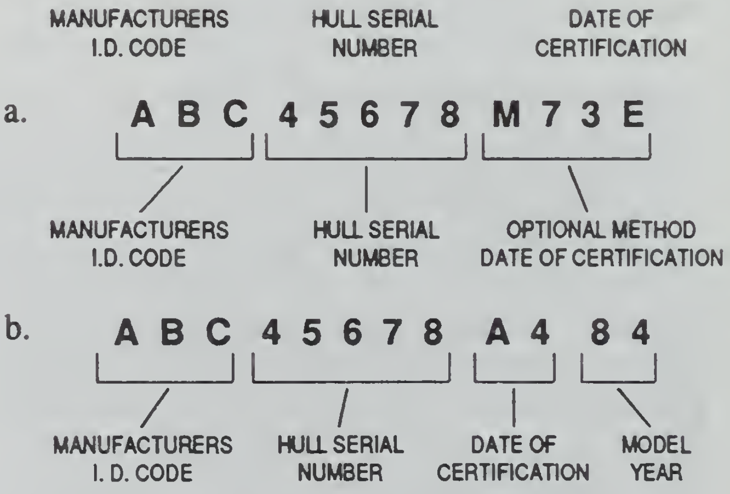


Fig. 2-2. Hull Identification Number

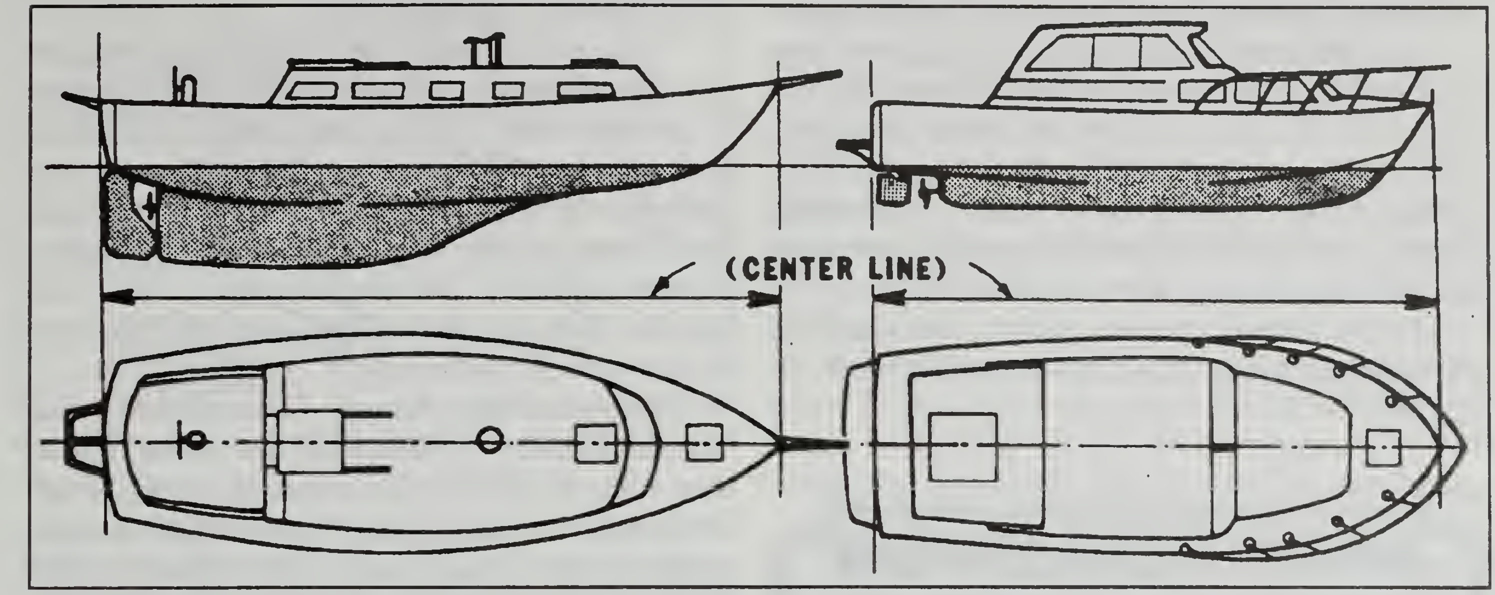


Fig. 2-3. Measuring a Boat

Since August 1, 1984 a new format has been used (fig. 2-2b). In it, the ninth character shows the month construction began. In this system, "A" stands for January. Character 10 is the last digit of the year of manufacture. Characters 11 and 12 are the model year.

Your boat's HIN must appear in two places. If it has a transom, the primary number is on its starboard side within two inches of its top. If it does not have a transom or if it was not practical to use the transom, the number is on the starboard side. In this case, it must be within one foot of the stern and within two inches of the top of the hull side. On pontoon boats, it is on the aft crossbeam within one foot of the starboard hull attachment.

Your boat also has a duplicate number in an unexposed location. This is on the boat's interior or under a **FITTING** or item of hardware.

Length of Boats

For some purposes, boats are classed by length. Required equipment, for example, differs with boat size.

Manufacturers may measure a boat's length in several ways. Officially, though, your boat is measured along a straight line from its bow to its stern. This line is parallel to its keel. The length does not include **BOWSPRITS, BOOMKINS,** or **PULPITS.** Nor does it include rudders, brackets, outboard motors, outdrives, diving platforms, or other attachments.

Capacity Information

Manufacturers must put **CAPACITY PLATES** on most monohull recreational motorboats less than 20 feet long.[1] Sailboats, canoes, kayaks, and inflatable boats are exempt. Outboard boats must display the maximum permitted horsepowers of their engines. The plates must also show the allowable maximum weights of the people on board. And they must show the allowable maximum combined weights of people, motors, and gear (fig. 2-4). Inboards and stern drives need not show the weight of their engines on their capacity plates (fig. 2-5).

The capacity plate must appear where it is clearly visible to the operator when getting **UNDERWAY**. This information serves to remind you of the capacity of your boat under normal circumstances. You should ask yourself, "Is my boat loaded above its recommended capacity?" and, "Is my boat overloaded for the present sea and wind conditions?" If you are stopped by a legal authority, you may be cited if you are overloaded.

---

[1] A table of English-Metric and Metric-English equivalents appears as Appendix D of this book.

Manufacturer's Certificate of Compliance

Manufacturers are required to put ***COMPLIANCE* PLATES** on motorboats less than 20 feet long. The plates must say, “This boat,” or “This equipment complies with the U. S. Coast Guard Safety Standards in effect on the date of certification.” Letters and numbers can be no less than one-eighth of an inch high.

At the manufacturer's option, the capacity and compliance plates may be combined as in figure 2-7.

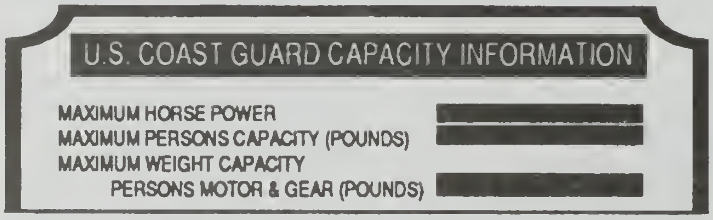

U.S. COAST GUARD CAPACITY INFORMATION
MAXIMUM HORSE POWER
MAXIMUM PERSONS CAPACITY (POUNDS)
MAXIMUM WEIGHT CAPACITY
PERSONS MOTOR & GEAR (POUNDS)

Fig. 2-4. Capacity Plate for Outboards

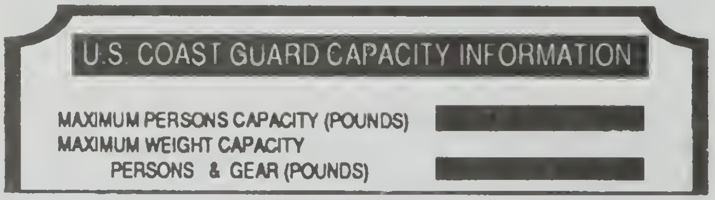

U.S. COAST GUARD CAPACITY INFORMATION
MAXIMUM PERSONS CAPACITY (POUNDS)
MAXIMUM WEIGHT CAPACITY
PERSONS & GEAR (POUNDS)

Fig. 2-5. Capacity Plate for Inboards

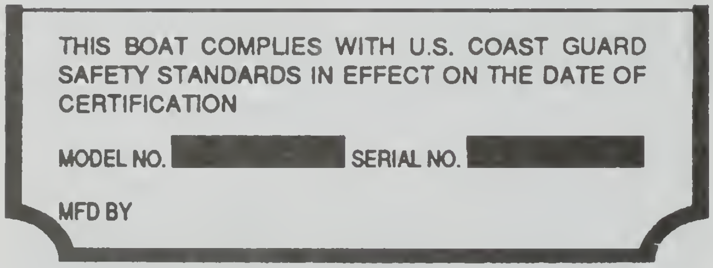

THIS BOAT COMPLIES WITH U.S. COAST GUARD SAFETY STANDARDS IN EFFECT ON THE DATE OF CERTIFICATION
MODEL NO.
SERIAL NO.
MFD BY

Fig. 2-6. Compliance Plate

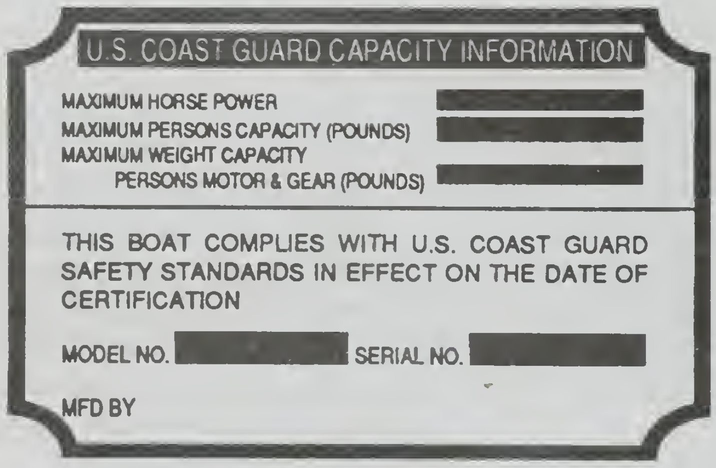

U.S. COAST GUARD CAPACITY INFORMATION
MAXIMUM HORSE POWER
MAXIMUM PERSONS CAPACITY (POUNDS)
MAXIMUM WEIGHT CAPACITY
PERSONS MOTOR & GEAR (POUNDS)
THIS BOAT COMPLIES WITH U.S. COAST GUARD SAFETY STANDARDS IN EFFECT ON THE DATE OF CERTIFICATION
MODEL NO.
SERIAL NO.
MFD BY

Fig. 2-7. Combination Capacity and Compliance Plate

Your Boat's Ventilation

“A cup of gasoline spilled in the **BILGES** has the potential explosive power of 15 sticks of dynamite!” This statement, commonly quoted over 20 years ago, may be an exaggeration. However, it illustrates a fact. Gasoline fumes in the bilge of a boat are highly explosive and a serious danger. They are heavier than air and will stay in the bilge until they are vented out.

Because of this danger, Coast Guard regulations require ventilation on many power boats. There are several ways to supply fresh air to engine and gasoline tank compartments and to remove dangerous vapors. Whatever the choice, it must meet Coast Guard standards.

The following discussion does not deal with all of the regulations nor does it cover all recreational boats. It deals only with:

1. boats built after July 31, 1980,
2. vessels made or used noncommercially,
3. vessels leased, rented, or chartered for noncommercial use, and
4. boats carrying six or fewer passengers for hire.

Neither is it intended to be a complete discussion of the regulations. It is limited to the majority of recreational vessels.

General Precautions

Ventilation systems will not remove raw gasoline that leaks from tanks or fuel lines. If you smell gasoline fumes, you need immediate repairs. The best device for sensing gasoline fumes is your nose. **Use it!** If you smell gasoline in an engine compartment or elsewhere, **don’t start your engine**. The smaller the compartment, the less gasoline it takes to make an explosive mixture.

Play it safe--keep your boat free of explosive vapors!

Ventilation for Open Boats

In open boats, gasoline vapors are dispersed by the air that moves through them. So they are exempt from ventilation requirements.

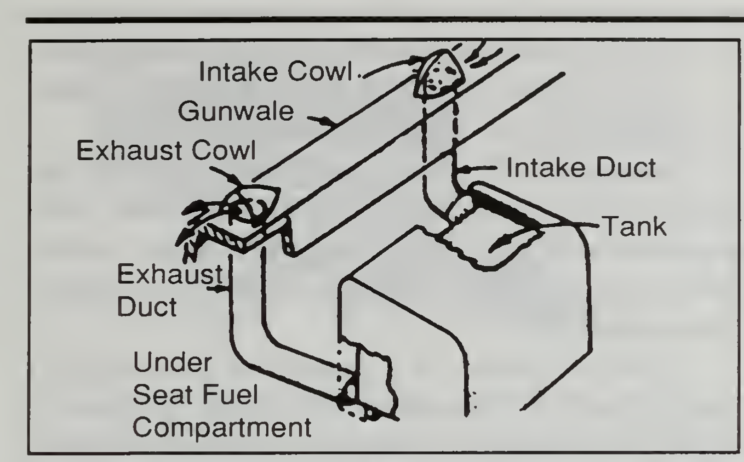


Fig. 2-8. A Natural Ventilation System

To be "open," a boat must meet certain conditions. Engine and fuel tank compartments and long narrow compartments that join them must be "open to the atmosphere." This means they must have at least 15 square inches of open area for each cubic foot of net compartment volume. The open area must be in direct contact with the atmosphere. There must also be no long, unventilated spaces open to engine and fuel tank compartments into which flames could extend.

Ventilation Systems

There are two types of ventilation systems. One is "natural ventilation." In it, air circulates through closed spaces due to the boat's motion. The other type is "powered ventilation." In it, air is circulated by a motor driven fan or fans.

Natural Ventilation System Requirements

A natural ventilation system has an air supply from outside the boat. The air supply may also be from a ventilated compartment or a compartment open to the atmosphere. Intake openings are required. In addition, intake ducts may be required to direct the air to appropriate compartments.

The system must also have an exhaust duct that starts in the lower third of the compartment. The exhaust opening must be into another ventilated compartment or into the atmosphere.

Each supply opening and supply duct, if there is one, must be above the usual level of water in the bilge. Exhaust openings and ducts must also be above the bilge water. Openings and ducts must be at least three square inches in area or two inches in diameter. Openings are placed so exhaust gasses do not enter the fresh air intake. Exhaust fumes must not enter cabins nor other enclosed, non-ventilated spaces. The carbon monoxide gas in them is deadly.

Intake and exhaust openings must be covered by **COWLS** or similar devices. These registers keep out rain water and water from breaking seas. Most often, intake registers face forward and exhaust openings aft. This aids the flow of air when the boat is moving or at anchor since most boats face into the wind when anchored.

**Inspect ducts frequently.
Plastic ducts can break.
Ducts can come loose.**

Powered Ventilation System Requirements

Powered ventilation systems must meet the standards of a natural system. They must also have one or more exhaust blowers (see fig. 2-10). The blower duct can serve as the exhaust duct for natural ventilation if fan blades do not obstruct the air flow when not powered.

Openings in engine compartments for carburetion are in addition to ventilation system requirements.

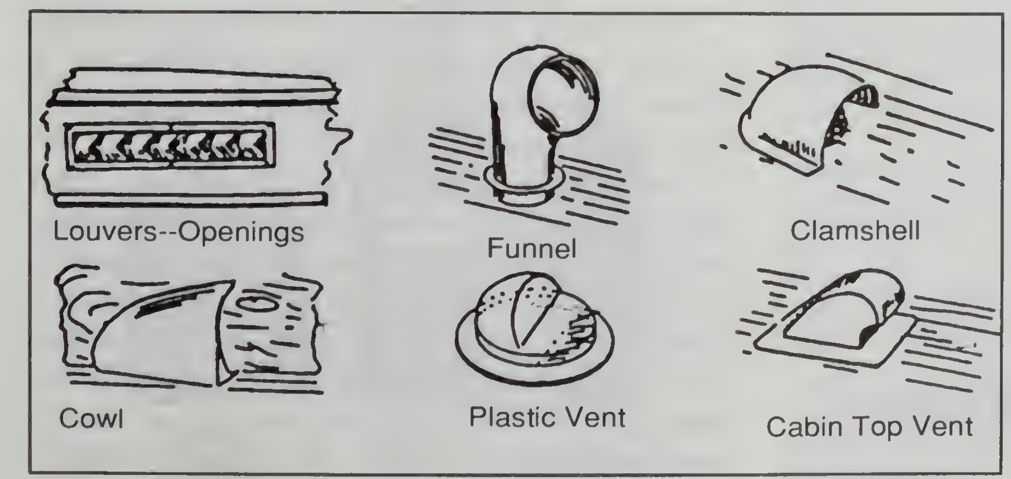


Fig. 2-9. Acceptable Intake Openings

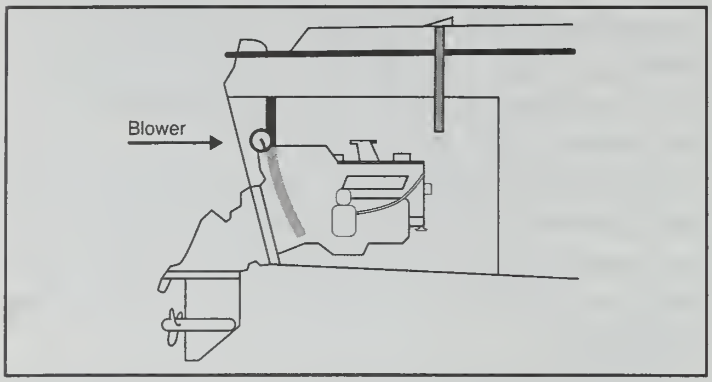


Fig. 2-10. Powered Ventilation in Closed Engine Compartment

Boats Requiring Ventilation Systems

Powered and natural ventilation are required in an enclosed compartment with a permanently installed gasoline engine that has a cranking motor. A compartment is exempt if its engine is open to the atmosphere. Diesel powered boats are also exempt.

Natural Ventilation System Required. Natural ventilation is required for each enclosed compartment in a boat that has one or more of the following:

1. a permanently installed gasoline engine,
2. sufficiently large openings between it and a compartment that requires ventilation,
3. a permanently installed fuel tank and an electrical part that is not ignition-protected so that it may produce sparks,
4. a fuel tank that vents into that compartment, or
5. a nonmetallic fuel tank that exceeds technical requirements for permeability. (Some plastic tanks "bleed" excessively.)

Table 2-1

Ventilation for Power Boats
(Vessels Built After July 31, 1980)

Type of Boat	Powered Ventilation	Natural Ventilation
Open boat	No	No
Open boat with portable tank	No	No
Portable tank in enclosed compartment	No	Yes*
Permanent tank vented to outside	No	No
Permanent tank *and* engine compartment	Yes	Yes
Permanent tank and engine compartments**		
Tank compartment	No	No***
Engine compartment	Yes	Yes

* This table assumes that portable tanks are not vented to the outside.

** This table assumes that permanently installed tanks are vented to the outside.

*** If electrical components are present, they must be ignition-protected.

Compartments open to the atmosphere do not require ventilation. Nor do fuel tank compartments if the tanks vent to the open atmosphere and electrical parts in them are ignition-protected.

Gasoline tanks with capacities greater than seven gallons are sometimes called "portable." The Coast Guard Auxiliary considers them to be permanent tanks and requires that they be permanently secured before a boat can be awarded its safety decal.

Table 2-1 lists the ventilation requirements for a variety of boat configurations.

Warning Label. On boats with powered ventilation, there must be warning labels. One must be mounted near each ignition switch, in plain view of the operator. The label must have at least the following information:

WARNING
Gas vapors can explode.
Before starting engine, operate
blower for four minutes and
check engine compartment bilge
for gas vapors.

Backfire Flame Arresters

Gasoline engines, other than outboards, must have acceptable means of backfire control. Backfires occur when flames from an engine exit through the carburetor instead of the exhaust system. A backfire control keeps the flames from entering the engine compartment.

The usual method of controlling backfires is by a backfire flame arrester (fig. 2-11). A flame arrester works by rapidly dissipating the heat of the flame. Thus, the flame is kept out of the engine compartment. There are other approved methods of backfire control that keep backfire flames out of engine compartments. An acceptable backfire flame arrester bears a Coast Guard approval number, or it shows that it complies with Underwriters Laboratories Standard UL 1111, or the label states that it complies with the Society of Automotive Engineers Standard SAE J-1928.

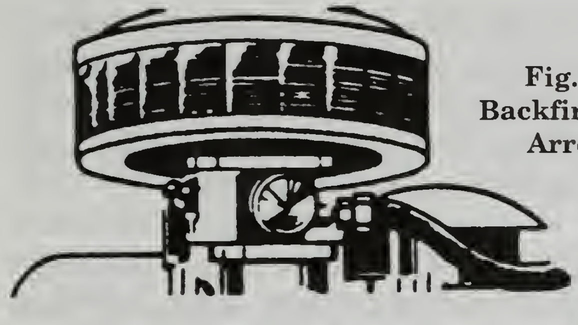


Fig. 2-11. Backfire Flame Arrester

To be effective, flame arresters must be free of oil, grease, and dirt. Grease dissolving detergents are available for this purpose. Other than periodic cleaning, backfire flame arresters do not need servicing or replacement.

YOUR BOAT'S EQUIPMENT

Coast Guard regulations require that your boat have certain equipment aboard. These requirements are minimums. Exceed them whenever you can.

Fire Extinguishers

If your motorboat meets one or more of the following conditions, you must have at least one fire extinguisher aboard. The conditions are:

1. inboard or stern drive engines,
2. closed compartments under **THWARTS** and seats where portable fuel tanks can be stored,
3. double bottoms not sealed together or not completely filled with flotation materials,
4. closed living spaces,
5. closed stowage compartments in which combustible or flammable materials are stored,
6. permanently installed fuel tanks, and
7. it is 26 feet or more in length.

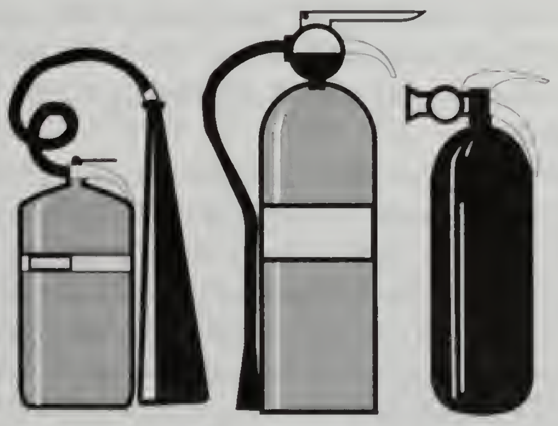


Fig. 2-12. Typical Fire Extinguishers

Table 2-2

Class B Fire Extinguishers

Coast Guard classification (type-size)	Underwriter's Laboratory Listing	Carbon Dioxide (lbs.)	Dry Chemical (lbs.)	Halon (lbs.)
B-I	5B	4	2	2.5
B-II	10B	15	10	10

Types of fires. Fire extinguishers have labels that tell the types of fires for which they are designed.

There are three common classes of fires.

- Class A fires are in ordinary combustible materials such as paper or wood.
- Class B fires involve gasoline, oil, and grease.
- Class C fires are electrical.

The extinguishers on motorboats must be for Class B fires. Never use water on Class B or Class C fires. Water spreads Class B fires. Water may cause you to be electrocuted in a Class C fire.

Sizes of Extinguishers. Fire extinguishers are also classed by the amount of material they contain. Table 2-2 lists the types of Class B extinguishers and their contents.

Contents of Extinguishers. Fire extinguishers use a variety of materials. Those used on boats usually contain dry chemicals, halon, or carbon dioxide (CO_2). Dry chemical extinguishers contain chemical powders such as sodium bicarbonate—baking soda.

Carbon dioxide is a colorless and odorless gas when released from an extinguisher. It is not poisonous but caution must be used in entering compartments filled with it. It will not support life and keeps oxygen from reaching your lungs. A fire-killing concentration of carbon dioxide is lethal. If you are in a compartment with a high concentration of CO_2, you will have no difficulty breathing. But the air does not contain enough oxygen to support life. Unconsciousness or death can result.

Halon Extinguishers. Some fire extinguishers and 'built-in' or 'fixed' automatic fire extinguishing systems contain a gas called halon. Like carbon dioxide it is colorless and odorless and will not support life. Some halons may be toxic if inhaled.

To be acceptable to the Coast Guard, a fixed halon system must have an indicator light at the vessel's helm (fig. 2-13). A green light shows the system is ready. Red means it is being discharged or has been discharged. Warning horns are available to let you know the system has been activated. If your fixed halon system discharges, ventilate the space thoroughly before you enter it. There are no residues from halon but it will not support life.

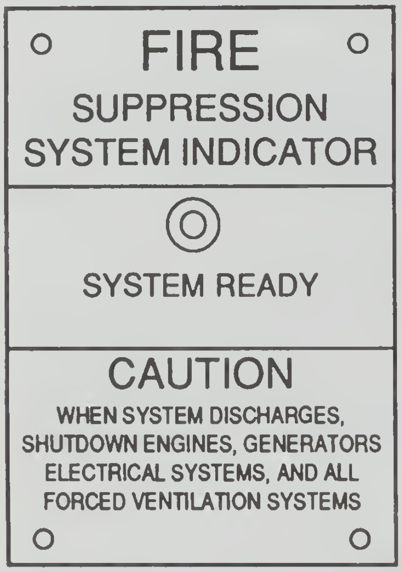

FIRE
SUPPRESSION
SYSTEM INDICATOR
SYSTEM READY
CAUTION
WHEN SYSTEM DISCHARGES, SHUTDOWN ENGINES, GENERATORS ELECTRICAL SYSTEMS, AND ALL FORCED VENTILATION SYSTEMS

Fig. 2-13. Fire Suppression Indicator

Although halon has excellent fire fighting properties, it is thought to deplete the earth's ozone layer and has not been manufactured since January 1, 1994. Halon extinguishers can be refilled from existing stocks of the gas until they are used up, but high federal excise taxes are being charged for the service. If you discontinue using your halon extinguisher, take it to a recovery station rather than releasing the gas into the atmosphere.

Compounds such as FE 241, designed to replace halon, are now available.

Obsolete Extinguishers. Some other extinguishers also require caution. If you have an old carbon tetrachloride extinguisher, safely dispose of it. In contact with a flame, it produces phosgene, a poisonous gas used in World War I.

Some obsolete hand-portable extinguishers must be inverted to be activated. Some must be inverted and bumped. These extinguishers are either ineffective on boat fires or dangerous to use. They include soda-acid, foam, and cartridge operated water extinguishers. Neither soda-acid nor cartridge operated extinguishers should be used on gasoline, oil, or grease fires such as occur on boats. They contain water. All are potentially dangerous. If their discharge hoses are blocked, they may explode. Safely dispose of them, too.

Fire Extinguisher Approval. Fire extinguishers must be Coast Guard approved. Look for the approval number on the nameplate. Approved extinguishers have the following on their labels: "Marine Type USCG Approved, Size..., Type..., 162.208/," etc. In addition, to be acceptable by the Coast Guard, an extinguisher must be in serviceable condition and mounted in its bracket.

Care and Treatment. Make certain your extinguishers are in their stowage brackets and are not damaged. Replace cracked or broken hoses. Nozzles should be free of obstructions. Sometimes, wasps and other insects nest inside nozzles and make them inoperable.

Check your extinguishers frequently. If they have pressure gauges, is the pressure within acceptable limits? Do the locking pins and sealing wires show they have not been used since recharging?

Don't try an extinguisher to test it. Its valves will not reseat properly and the remaining gas will leak out. When this happens, the extinguisher is useless.

Weigh and tag carbon dioxide, halon or compound FE 241 extinguishers twice a year. If their weight loss exceeds 10 percent of the weight of the *charge,* recharge them. Check to see that they have not been used. They should have been inspected by a qualified person within the past six months, and they should have tags showing all inspection and service dates. The problem is that they can be partially discharged while appearing to be fully charged.

Some halon extinguishers have pressure gauges the same as dry chemical extinguishers. Don't rely too heavily on the gauge. The extinguisher can be partially discharged and still show a good gauge reading. Weighing a halon extinguisher is the only accurate way to assess its contents.

If your dry chemical extinguisher has a

pressure indicator, check it frequently. Check the nozzle to see if there is powder in it. If there is, recharge it. Occasionally invert your dry chemical extinguisher and hit the base with the palm of your hand. The chemical in these extinguishers packs and cakes due to the boat's vibration and pounding. There is a difference of opinion about whether hitting the base helps, but it can't hurt. It is known that caking of the chemical powder is a major cause of failure of dry chemical extinguishers. Carry spares in excess of the minimum requirement.

If you have guests aboard, make certain they know where the extinguishers are and how to use them.

Using a Fire Extinguisher. A fire extinguisher usually has a device to keep it from being discharged accidentally. This is a metal or plastic pin or loop. If you need to use your extinguisher, take it from its bracket. Remove the pin or the loop and point the nozzle at the base of the flames. Now, squeeze the handle, and discharge the extinguisher's contents while sweeping from side to side. Recharge a used extinguisher as soon as possible.

If you are using a halon or carbon dioxide extinguisher, keep your hands away from the discharge. The rapidly expanding gas will freeze them. If your fire extinguisher has a horn, hold it by its handle.

Legal Requirements for Extinguishers. You must carry fire extinguishers as defined by Coast Guard regulations. They must be firmly mounted in their brackets and *immediately* accessible.

A motorboat less than 26 feet long must have at least one approved hand-portable, Type B-I extinguisher. If the boat has an approved fixed fire extinguishing system, you are not required to have the Type B-I extinguisher. Also, if your boat is less than 26 feet long, is propelled by an outboard motor, or motors, and does not have any of the first six conditions described at the beginning of this section, it is not required to have an extinguisher. Even so, it's a good idea to have one, especially if a nearby boat catches fire, or if a fire occurs at a fuel dock.

Table 2-3

Minimum Number of Hand Portable Fire Extinguishers With and Without Fixed Extinguishing Systems

Length of Vessel	No fixed system in machinery space	Fixed fire extinguishing system in machinery space
Less than 26 feet	1 B-I	none
26 ft. to under 40 ft.	2 B-I or 1 B-11	1 B-1
40 feet to 65 feet	3 B-I or 1 B-I and 1 B-II	2 B-I or 1 B-II

A motorboat 26 feet to under 40 feet long, must have at least two Type B-I approved hand-portable extinguishers. It can, instead, have at least one Coast Guard approved Type B-II. If you have an approved fixed fire extinguishing system, only one Type B-I is required.

A motorboat 40 to 65 feet long must have at least three Type B-I approved portable extinguishers. It may have, instead, at least one Type B-I *plus* one Type B-II. If there is an approved fixed fire extinguishing system, two Type B-I or one Type B-II is required.

The minimum number of hand portable fire extinguishers required for each class of vessel is listed in table 2-3.

Warning System. Various devices are available to alert you to danger. These include fire, smoke, gasoline fumes, and carbon monoxide detectors. If your boat has a galley, it should have a smoke detector. Where possible, use wired detectors. Household batteries often corrode rapidly on a boat.

You can't see, smell, nor taste carbon monoxide gas, but it is lethal. As little as one part in 10,000 parts of air can bring on a headache. The symptoms of carbon monoxide poisoning—headaches, dizziness, and nausea—are like sea sickness. By the time you realize what is happening to you, it may be too late to take action. If you have enclosed living spaces on your boat, protect yourself with a detector. There are many ways in which carbon monoxide can enter your boat.

Personal Flotation Devices

PERSONAL FLOTATION DEVICES (PFDs) are commonly called life preservers or life jackets. You can get them in a variety of types and sizes. They vary with their intended uses. To be acceptable, they must be Coast Guard approved.

Type I PFDs. A Type I life jacket is also called an **OFFSHORE LIFE JACKET** (see fig. 2-14). Type I life jackets will turn most unconscious people from facedown to vertical or slightly backward positions. The adult size gives a minimum of 22 pounds of buoyancy. The child size has at least 11 pounds. Type I jackets provide more protection to their wearers than any other type of life jacket.

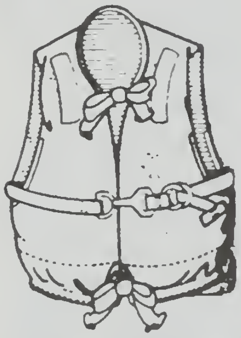


Fig. 2-14. Type I Off-shore Life Jacket

Type I life jackets are bulkier and less comfortable than other types. Furthermore, there are only two sizes, one for children and one for adults.

Type I life jackets will keep their wearers afloat for extended periods in rough water. They are recommended for offshore cruising where a delayed rescue is probable.

Type II PFDs. A Type II life jacket is also called a **NEAR-SHORE BUOYANT VEST**. It is an approved, wearable device. Type II life jackets will turn some unconscious people from facedown to vertical or slightly backward positions. The adult size gives at least 15.5 pounds of buoyancy. The medium child size has a minimum of 11 pounds. And the small child and infant sizes give seven pounds.

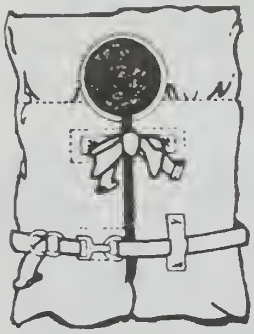


Fig. 2-15. Type II Near-shore Buoyant Vest

A Type II life jacket is more comfortable than a Type I but it does not have as much buoyancy. It is not recommended for long hours in rough water. Because of this, Type IIs are recommended for inshore and inland cruising on calm water. Use them where there is a good chance of fast rescue.

Fig. 2-16. Type III Flotation Aid
(Courtesy of Mustang (USA) Corporation)

Type III PFDs. Type III life jackets or Marine Buoyant Devices are also known as **FLOTATION AIDS**. Like Type IIs, they are designed for calm inland or close offshore water where there is a good chance of fast rescue. Their minimum buoyancy is 15.5 pounds. They will not turn their wearers face up.

Type III devices are usually worn where freedom of movement is necessary. Thus, they are used for water skiing, small boat sailing, and fishing among other activities. They are available as vests and flotation coats. Flotation coats are useful in cold weather. Type IIIs come in many sizes from small child through large adult.

Life jackets come in a variety of colors and patterns—red, blue, green, camouflage, and cartoon characters. From a safety standpoint, the best color is bright orange. It is easier to see in the water, especially if the water is rough.

Type IV PFDs. Type IV Ring Life Buoys, Buoyant Cushions and Horseshoe Buoys are Coast Guard approved devices called **THROWABLES**. They are made to be thrown to people in the water, and should not be worn.

Type IV *cushions* are often used as seat

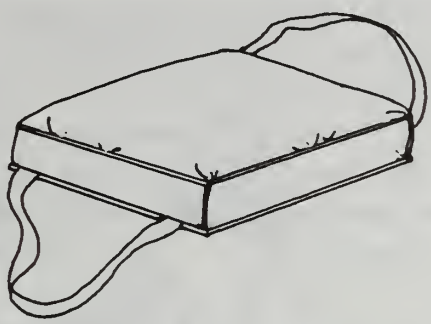


Fig. 2-17. Type IV Buoyant Cushion

cushions. Cushions are hard to hold onto in the water. Thus, they do not afford as much protection as wearable life jackets.

The straps on buoyant cushions are for you to hold onto either in the water or when throwing them. A cushion should never be worn on your back. It will turn you face down in the water.

Type IV *throwables* are not designed as personal flotation devices for unconscious people, nonswimmers, or children. Use them only in emergencies. They should not be used for long periods in rough water.

Ring life buoys come in 18, 20, 24, and 30 inch diameter sizes. They have grab lines. You should attach about 60 feet of polypropylene line to the grab rope to aid in retrieving someone in the water. If you throw a ring, be careful not to hit the person. Ring buoys can knock people unconscious.

Type V PFDs. Type V PFDs are of two kinds, **SPECIAL USE DEVICES** and **HYBRIDS**. Special use devices include boardsailing vests, deck suits, work vests, and others. They are approved only for the special uses or conditions indicated on their labels. Each is designed and intended for the particular application shown on its label. They do not meet legal requirements for general use aboard recreational boats.

Hybrid life jackets are inflatable devices with some built-in buoyancy provided by plastic foam or kapok. They can be inflated orally or by cylinders of compressed gas to give additional buoyancy. In some hybrids the gas is released manually. In others it is released automatically when the life jacket is immersed in water.

The inherent buoyancy of a hybrid may be insufficient to float a person unless it is inflated. The only way to find this out is for the user to try it in the water. Because of its limited buoyancy when deflated, a hybrid is recommended for use by a non-swimmer only if it is worn with enough inflation to float the wearer.

If they are to count against the legal requirement for the number of life jackets you must carry on your vessel, hybrids manufactured before *February 8, 1995* must be worn whenever a boat is underway and the wearer is not below decks or in an enclosed space. To find out if your Type V hybrid must be worn to satisfy the legal requirement, read its label. If its use is restricted it will say, "REQUIRED TO BE WORN" in capital letters.

Hybrids cost more than other life jackets, but this factor must be weighed against the fact that they are more comfortable than Type I, II, or III life jackets. Because of their greater comfort, their owners are more likely to wear them than are the owners of Type I, II, or III life jackets.

The Coast Guard has determined that improved, less costly hybrids can save lives since they will be bought and used more frequently. For these reasons a new federal regulation was adopted effective February 8, 1995. The regulation increases both the deflated and inflated buoyancies of hybrids, makes them available in a greater variety of sizes and types, and reduces their costs by reducing production costs. Unlike older hybrids, the newer ones are no longer required to be worn when above decks or not in enclosed spaces to be approved.

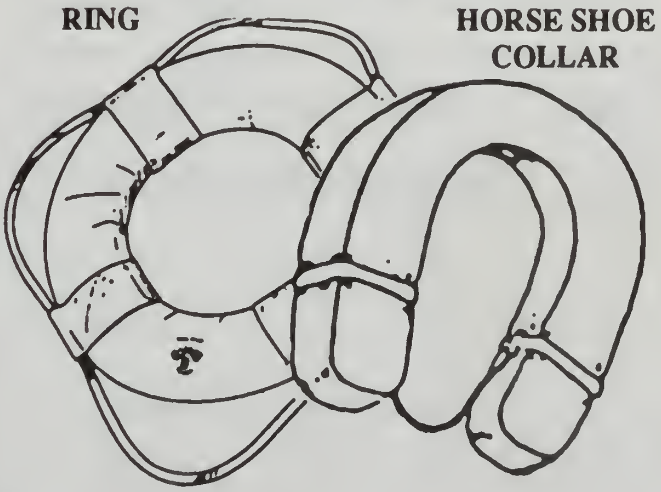


Fig. 2-18. Type IV PFDs—Throwables

Even though it may not be required, the wearing of a hybrid or a life jacket is encouraged whenever a vessel is underway.

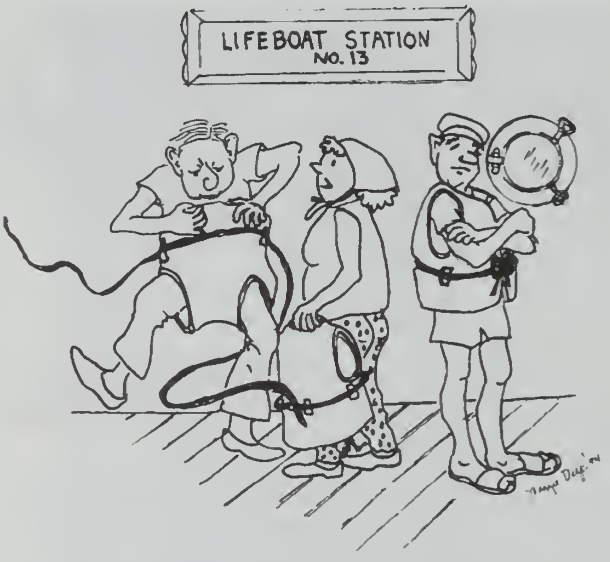
Like life jackets, hybrids are now available in three types. To meet legal requirements, a Type I hybrid can be substituted for a Type I life jacket. Similarly Type II and III hybrids can be substituted for Type II and Type III life jackets. A Type I hybrid, when inflated, will turn most unconscious people from face-down to vertical or slightly backward positions just like a Type I life jacket. Type II and III hybrids function like Type II and III life jackets. Inflated and deflated buoyancies for adult, youth, and small child sizes of the three types of hybrid life jackets are given in table 2-4.

If you purchase a new hybrid, it should have an owner's manual attached which describes its life jacket type and its deflated and inflated buoyancies. It warns you that it may have to be inflated to float you. The manual also tells you how to don the life jacket and how to inflate it. It also tells you how to change its inflation mechanism, recommended testing exercises, and inspection and maintenance procedures. The manual also tells you why you need a life jacket and why you should wear it.

A new hybrid must be packaged with at least three gas cartridges. One of these may already be loaded into the inflation mechanism. Likewise, if it has an automatic inflation mechanism, it must be packaged with at least three of these water sensitive elements. One of these elements may be installed.

Table 2-4. Buoyancies for Hybrid Life Jackets on Recreational Vessels

Type	Sizes Adult	Youth	Small Child
	Inherent Buoyancy (Deflated):		
I	15.5	11	9
II	10	9	7
III	10	9	N/A
V	7.5	7.5	N/A
	Total Buoyancy (Inflated):		
I	30	18	15
II	22	15	12
III	22	15	N/A
V	22	15	N/A



Somehow I don't think that's quite right, Dear.....

Legal Requirements

A Coast Guard approved life jacket must show the manufacturer's name and approval number. Most are marked as Type I, II, III, IV, or V. All of the newer hybrids are marked for type.

You are required to carry at least one wearable life jacket or hybrid for each person on board your recreational vessel. If your vessel is 16 feet or more in length and is not a canoe or a kayak, you must also have at least one Type IV on board. These requirements apply to all recreational vessels that are propelled or controlled by machinery, sails, oars, paddles, poles, or another vessel. Sailboards are not required to carry life jackets.

You can substitute an older Type V hybrid for any required Type I, II, or III life jacket provided that its approval label shows it is:

1. approved for the activity the vessel is engaged in,
2. approved as a substitute for a life jacket of the type required on the vessel,
3. used as required on the labels, and
4. used in accordance with any requirements in its owner's manual, if the approval label makes reference to such a manual.

A water skier being towed is considered to be on board the vessel when judging compliance with legal requirements.

You are required to keep your Type I, II, or III life jackets or equivalent hybrids *readily* accessible, which means you must be able to get to them quickly if they are needed. Type

IV devices must be *immediately* available. This means you must be able to reach out and get them when needed. All life jackets must be in good and serviceable condition. All Type V hybrids must be worn whenever the boat is underway and the wearer is not below decks or in an enclosed space.

General Considerations

The proper use of a life jacket requires the wearer to know how it will perform. You can gain this knowledge only through experience.

Each person on your boat should be assigned a life jacket. Next, it should be fitted to the person who will wear it. Only then can you be sure that it will be ready for use in an emergency. Boats can sink fast. There may be no time to look around for a life jacket. Fitting one on you in the water is almost impossible.

This advice is good even if the water is calm, and you intend to boat near shore. Most drownings occur in inland waters within a few feet of safety. Most victims had life jackets, but they weren't wearing them.

Keeping life jackets in the plastic covers they came wrapped in and in a cabin assures that they will stay clean and unfaded. But this is no way to keep them when you are on the water. When you need a life jacket it must be *readily* accessible and adjusted to fit you. You can't spend time hunting for it or learning how to fit it.

There is no substitute for the experience of entering the water while wearing a life jacket. Children, especially, need practice. If possible, give your guests this experience. Tell them they should keep their arms to their sides when jumping in to keep the life jacket from riding up. Let them jump in and see how the life jacket responds. Is it adjusted so it does not ride up? Is it the proper size? Are all straps snug? Are children's life jackets the right sizes for them? Are they adjusted properly? If a child's life jacket fits correctly, you can lift the child by the jacket's shoulder straps and the child's chin and ears will not slip through.

Nonswimmers, children, handicapped persons, and elderly persons should always wear life jackets when they are aboard. Many states require that they wear them. In hazardous water or rough weather they should be worn by everyone aboard. Coast Guard members always wear life jackets when they are on the water even when it is calm.

Inspect your lifesaving equipment from time to time. Leave any questionable or unsatisfactory equipment on shore. An emergency is no time for you to conduct an inspection.

Indelibly mark your life jackets with your vessel's name, number, and calling port. This can be important in a search and rescue effort. It could help concentrate effort where it will do the most good.

Care of Life Jackets

Given reasonable care, life jackets last many years. Thoroughly dry them before putting them away. Stow them in dry, well-ventilated places. Avoid the bottoms of lockers and deck storage boxes where moisture may collect. Air and dry them frequently.

Life jackets should not be tossed about or used as **FENDERS** or cushions. Many contain kapok or fibrous glass material enclosed in plastic bags. The bags can rupture and are then unserviceable. Squeeze your life jacket gently. Does air leak out? If so, water can leak in and it will no longer be safe to use. Cut it up so no one will use it, and throw it away.

The covers of some life jackets are made of nylon or polyester. These materials are plastics. Like many plastics, they break down after extended exposure to the ultraviolet light in sunlight. This process may be more rapid when the materials are dyed with bright dyes such as "neon" shades.

Ripped and badly faded fabric are clues that the covering of your life jacket is deteriorating. A simple test is to pinch the fabric between your thumbs and forefingers. Now try to tear the fabric. If it can be torn, it should definitely be destroyed and discarded.

Compare the colors in protected places to those exposed to the sun. If the colors have faded, the materials have been weakened. A fabric covered life jacket should ordinarily last several boating seasons with normal use. A life jacket used every day in direct sunlight should probably be replaced more often.

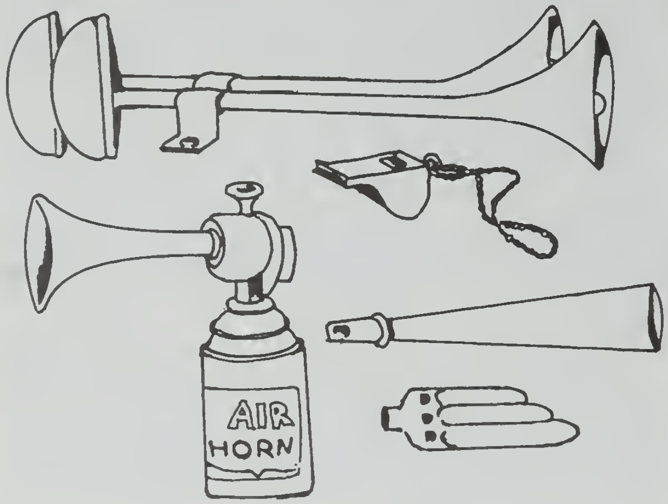


Fig. 2-19. Whistle and Horns

Sound Producing Devices

All boats are required to carry some means of making an efficient sound signal.

Devices for making the whistle or horn noises required by the Navigation Rules must be capable of a four second blast. The blast should be audible for at least one-half mile. Athletic whistles are not acceptable on boats 12 meters or longer. Use caution with athletic whistles. When wet, some of them come apart and loose their "pea." When this happens, they are useless.

If your vessel is 12 meters long and less than 20 meters, you must have a power whistle (or power horn) and a bell on board. The bell must be in operating condition and have a minimum diameter of at least 200 mm (7.9 inches) at its mouth.

Fig. 2-20. Bell

Visual Distress Signals

VISUAL DISTRESS SIGNALS (VDS) attract attention to your vessel if you need help. They also help to guide searchers in search and rescue situations. Be sure you have the right kinds, and use them properly.

It is illegal to fire flares improperly. In addition, they cost the Coast Guard and its Auxiliary many wasted hours in fruitless searches. If you signal a distress with flares and then someone helps you, please let the Coast Guard or the appropriate search and rescue agency (SAR) know so the distress report will be cancelled.

Recreational boats less than 16 feet long must carry visual distress signals on coastal waters at night. Coastal waters are: 1. the ocean (territorial sea), 2. the Great Lakes, 3. bays or sounds that empty into 1 or 2, and 4. rivers over two miles across at their mouths upstream to where they narrow to two miles. All pyrotechnic VDS must be Coast Guard approved, readily accessible, serviceable, and not past the stamped expiration date.

Recreational boats 16 feet or longer must carry VDS at all times on coastal waters. The same requirement applies to boats carrying six or fewer passengers for hire. Open sailboats less than 26 feet long without engines are exempt in the daytime as are manually propelled boats. Also exempt are boats in organized races, regattas, parades, etc. Boats owned in the United States and operating on the high seas must be equipped with VDS.

A wide variety of signaling devices meet Coast Guard regulations. For pyrotechnic devices, a minimum of three must be carried. Any combination can be carried as long as it adds up to at least three signals for day use and at least three signals for night use. Three day/night signals meet both requirements. If possible, carry more than the legal requirement. These devices are listed in table 2-5.

The American flag flying upside down is a commonly recognized distress signal. It is not recognized in the Coast Guard regulations, though. In an emergency, your efforts would probably be better used in more effective signaling methods.

Types of VDS

VDS are divided into two groups; daytime and nighttime use. Each of these groups is subdivided into pyrotechnic and non-pyrotechnic devices.

Daytime Non-Pyrotechnic Signals. A bright orange flag with a black square over a black circle is the simplest VDS (see fig. 2-21). It is usable, of course, only in daylight. It has the advantage of being a continuous signal.

A mirror can be used to good advantage on sunny days. It can attract the attention of other boaters and of aircraft from great distances. Mirrors are available with holes in their centers to aid in "aiming." In the absence of a mirror, any shiny object can be used.

When another boat is in sight, an effective VDS is to extend your arms from your sides and move them up and down. Do it slowly. If you do it too fast the other people may think you are just being friendly. This simple gesture is seldom misunderstood, and requires no equipment.

Daytime Pyrotechnic Devices. Orange smoke is a useful daytime signal. Hand-held or floating smoke flares are very effective in attracting attention from aircraft. Smoke flares don't last long, and are not very effective in high wind or poor visibility. As with other pyrotechnic devices, use them only when you know there is a possibility that someone will see the display.

To be usable, smoke flares must be kept dry. Keep them in airtight containers and store them in dry places. If the "striker" is damp, dry it out before trying to ignite the device. Some pyrotechnic devices require a forceful "strike" to ignite them.

Table 2-5

Visual Distress Signals

CG Approval Number	Description	Use
Pyrotechnic Visual Distress Signals		
160.021	Hand-Held Flare	Day/Night
160.022	Floating Orange Smoke	Day Only
160.024	Pistol Parachute Red Flare	Day/Night
160.036	Hand-Held Parachute Red Flare	Day/Night
160.037	Hand-Held Orange Smoke	Day Only
160.057	Floating Orange Smoke	Day Only
160.066	Red Aerial Pyrotechnic Flare	Day/Night
Non-Pyrotechnic Visual Distress Signals		
160.072	Orange Flag	Day Only
161.013	Electric Distress Light	Night Only

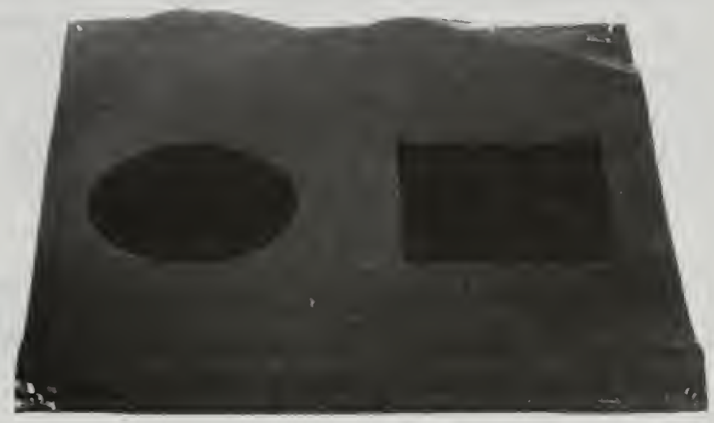


Fig. 2-21. Distress Flag
(Courtesy of Skyblazer® Signal Products)

All hand-held pyrotechnic devices may produce hot ashes or slag when burning. Hold them over the side of your boat in such a way that they do not burn your hand or drip into your boat.

Nighttime Non-Pyrotechnic Signals. An electric distress light is available. This light automatically flashes the international morse code SOS distress signal (••• – – – •••). Flashed four to six times a minute, it is an unmistakable distress signal. It must show that it is approved by the Coast Guard. Be sure the batteries are fresh. Dated batteries give assurance that they are current.

Under the Inland Navigation Rules, a high intensity white light flashing 50-70 times per

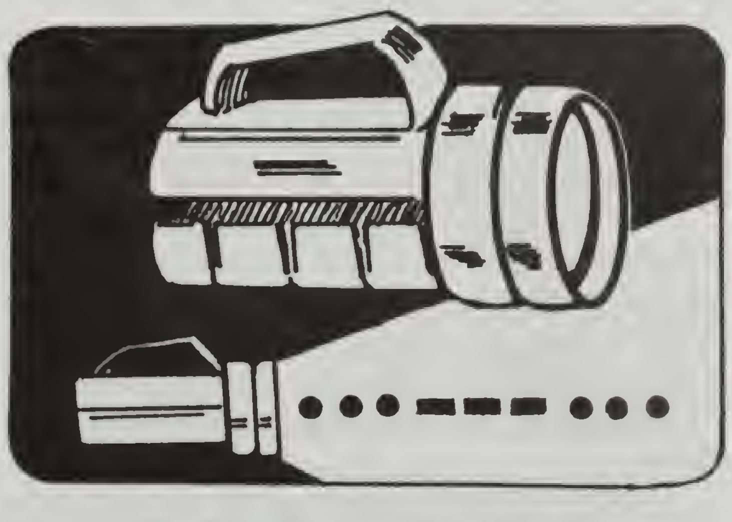


Fig. 2-22. Electric Distress Light

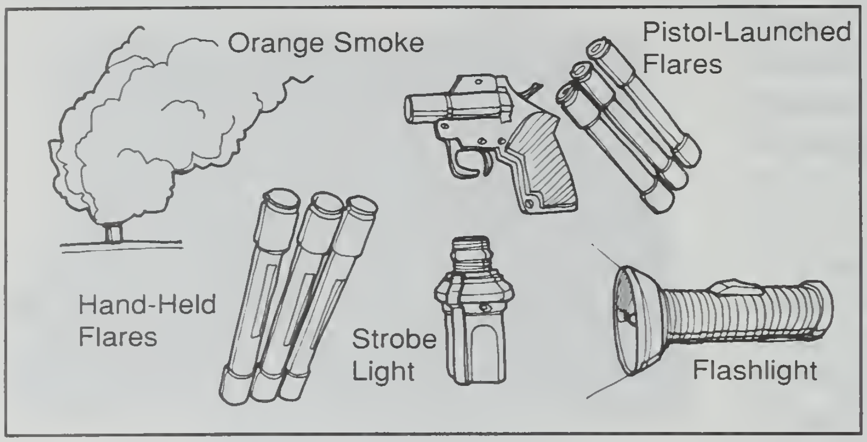


Fig. 2-23. Visual Distress Signals

minute is a distress signal. Therefore, use strobe lights on inland waters only for distress signals.

Nighttime Pyrotechnic Devices. Aerial and hand-held flares can be used at night or in the daytime. Obviously, they are more effective at night.

Currently, the serviceable life of a pyrotechnic device is rated at 42 months from its date of manufacture. Pyrotechnic devices are expensive. Look at their dates before you buy them. Buy them with as much time remaining as possible.

Like smoke flares, aerial and hand-held flares may fail to work if they have been damaged or abused. They will not function if they are or have been wet. Store them in dry, airtight containers in dry places. But store them where they are readily accessible.

Aerial VDSs, depending on their type and the conditions they are used in, may not go very high. Again, use them only when there is a good chance they will be seen.

A serious disadvantage of aerial flares is that they burn for only a short time. Most burn for less than 10 seconds. Most parachute flares burn for less than 45 seconds.

If you use a VDS in an emergency, do so carefully. Hold hand-held flares over the side of the boat when in use. *Never* use a road hazard flare on a boat. It can easily start a fire. Marine type flares are carefully designed to lessen risk, but they still must be used carefully.

Aerial flares should be given the same respect as firearms since they are firearms! *Never* point them at another person. *Don't* allow children to play with them or around them. When you fire one, face away from the wind. Aim it downwind and upward at an angle of about 60° to the horizon. If there is a strong wind, aim it somewhat more vertically. Never fire it straight up. Before you discharge a flare pistol, check for overhead obstructions. These might be damaged by the flare. They might deflect the flare to where it will cause damage.

Disposal of VDS. Keep outdated flares when you get new ones. They do not meet legal requirements, but you might need them sometime, and they may work. It is illegal to fire a VDS on federal navigable waters unless an emergency exists. Many states have similar laws.

Marine Sanitation Devices

There is no requirement to install toilet facilities if you do not have them. Installed toilets however, must have marine sanitation devices (MSD), certified by the Coast Guard, or holding tanks. It is illegal to have a non-approved MSD aboard in waters under federal jurisdiction. Some bodies of fresh water are no-discharge areas; know your local regulations. Holding tanks and portable toilets, such as porta-potties, must be emptied at land sites or approved mobile pumpout facilities.

Emergency Position Indicating Radio Beacon (EPIRB)

There is no requirement for recreational boats to have **EPIRBs** (see fig. 2-24). Some commercial and fishing vessels, though, must have them if they operate beyond the three mile limit. Vessels carrying six or fewer passengers for hire must have EPIRBs under some circumstances when operating beyond the three mile limit. If you boat in a remote area or offshore, you should have an EPIRB.

An EPIRB is a small (about 6 to 20 inches high), battery-powered, radio transmitting buoy-like device. It is a radio transmitter and requires a license or an endorsement on your radio station license by the Federal Communi-

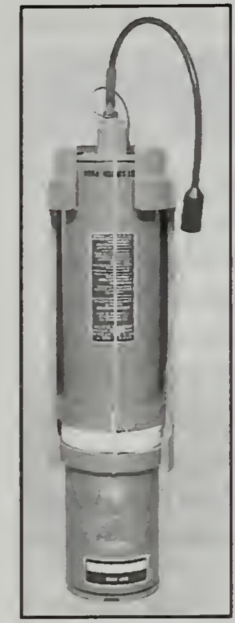


Fig. 2-24. Emergency Position Indicating Radio Beacon (Courtesy of ACR Electronics, Inc.)

cations Commission (FCC). EPIRBs are activated by being immersed in water or by a manual switch.

Two frequencies are in current use by EPIRBs, 121.5 Mhz (121s) and 406.025 Mhz (406s). The 121s were designed to have aircraft receive their signals. They are being phased out, although they are still effective homing devices for Coast Guard search and rescue teams. The Coast Guard highly recommends that recreational vessels carry 406s.

The 406 signals can be received worldwide by satellites. When a satellite receives a 406 signal, it records it and transmits it as it passes a land-based receiving station. A 406's signal can be pinpointed to within 3.2 to 6.4 nautical miles anywhere on the earth's surface. Some newer 406 EPIRBs also transmit 121 signals.

The newer 406 signals are uniquely coded for each unit. Your individual information is recorded in National Oceanic and Atmospheric Administration (NOAA) computers. This aids in search and rescue efforts by identifying your vessel's characteristics. It also helps reduce false alarms, which cause problems and subject owners to fines. Too often, EPIRBs are turned on during designated test periods and then are not turned off. If you test your 121, do so for only a few seconds during the period five minutes before the hour. When you test your 406, be certain that it is in the "test" mode.

If you buy a new or a used 406 EPIRB, you *must* register it with NOAA (National Oceanic and Atmospheric Administration). If you change your boat, your address, or your telephone number, you must reregister the 406 with NOAA. Request 406 MHz EPIRB registration forms from, and mail or fax the completed forms to: NOAA/NESDIS, SARSAT Operations Division E/SP3, Federal Office Building 4, Washington, DC 20233.

The biggest drawback of EPIRBs is their cost, which ranges upward from about $300 for 121.5s and considerably more for 406s. If you are thinking of buying an EPIRB, be sure it has been approved by the Federal Communications Commission (FCC).

Equipment Not Required But Recommended

Although not required by law, there is other equipment that is good to have aboard. Most of it is required for the Auxiliary's vessel examination.

Second Means of Propulsion. All boats less than 16 feet long should carry a second means of propulsion. A paddle or oar can come in handy at times. For most small boats, a spare trolling or outboard motor is an excellent idea. If you carry a spare motor, it should have its own fuel tank and starting power. If you use an electric trolling motor, it should have its own battery.

Dewatering Devices. All boats should carry at least one effective manual dewatering device in addition to any installed electric bilge pump. This can be a bucket, can, scoop, hand-operated pump, etc. If your battery "goes dead" it will not operate your electric pump.

First Aid Kit. All boats should carry a first aid kit. It should contain adhesive bandages, gauze, adhesive tape, antiseptic, aspirin, etc. Check your first aid kit from time to time. Replace anything that is outdated. It is to your advantage to know how to use your first aid kit. Take a Red Cross first aid course.

Anchors. All boats should have anchors. Choose one of suitable size for your boat. Better still, have two anchors of different sizes. Use the smaller one—your "lunch hook"—in calm water or when anchoring for a short time such as to fish or eat. Use the larger one when the water is rougher or for overnight anchoring.

Carry enough anchor line of suitable size for your boat and the waters in which you will operate. If your engine fails you, the first thing you usually should do is lower your anchor. This is good advice in shallow water where you may be driven aground by the wind or water. It is also good advice in windy weather or rough water. The anchor will usually hold your bow into the waves.

VHF-FM Radio. Your best means of summoning help in an emergency or in case of a breakdown is a VHF-FM radio. You can use it to get advice or assistance from the Coast Guard. In the event of a serious illness or injury aboard your boat, the Coast Guard can have emergency medical equipment meet you ashore. You will learn more about the use of a VHF-FM radio in chapter 11, "Your Boat's Radio."

Tools and Spare Parts. Carry a few tools and some spare parts, and learn how to make minor repairs. Many search and rescue cases are caused by minor breakdowns that boat operators could have repaired. If your engine is a stern drive or inboard, carry spare belts and impellers and the tools to change them with.

LEGAL CONSIDERATIONS

There are a number of legal considerations. Most of these involve nothing more than common sense and courtesy. All of them have been enacted to protect you, other people, or the environment.

Your Responsibility. In most states you are responsible for any damage your boat may cause other boats or injuries suffered by your passengers or others. You are responsible for anything your boat does or anything that happens to or on your boat if you are present or when it is used with your expressed or implied consent. For example, if your wake rocks another vessel and breaks dishes in the galley, you are responsible. If this happens when hot food is being prepared or served, you are liable for any personal injury. You can be cited for negligent or grossly negligent operation. The courteous thing to do when passing another vessel is to slow down enough that you do not create a large wake.

Federal law requires you to provide whatever assistance you can to anyone at sea in need of help. This means you must render assistance. It does not mean that you should endanger your passengers, your vessel, nor yourself to do so.

If you render assistance, you are protected by the "Good Samaritan" clause of the Federal Safe Boating Act of 1971. This act says that if you "gratuitously and in good faith" render assistance and there is no objection, you cannot be held liable for anything you do or don't do provided you act as an ordinary, reasonable person would have acted under the same or similar circumstances.

Law Enforcement. Federal regulations require that vessels underway, when hailed by the Coast Guard, **HEAVE TO** or maneuver in such a way that an officer can come aboard. Other federal, state, and local law enforcement officials may come aboard and examine your boat. With the exception of customs, you can recognize such boats by their markings, their blue lights, and the uniforms the personnel wear.

Discharge of Oil. All vessels under 100 gross tons must have a fixed or portable means of discharging oily bilge slops into a container. A bucket or bailer is acceptable. Any discharge that causes a sheen on the water is a violation of the Federal Water Pollution Control Act.

If your vessel is 26 feet or more in length you must post a placard stating the federal requirements. The placard must be at least five by eight inches. It must be made of durable material. Post it in the machinery spaces or at the bilge and ballast pump control station. It must state:

DISCHARGE OF OIL PROHIBITED

The Federal Water Pollution Control Act prohibits the discharge of oil or oily waste into or upon the navigable waters and contiguous zone of the United States if such discharge causes a film or sheen upon, or discoloration of, the surface of the water, or causes a sludge or emulsion beneath the surface of the water. Violators are subject to a penalty of $5,000.

Table 2-6*

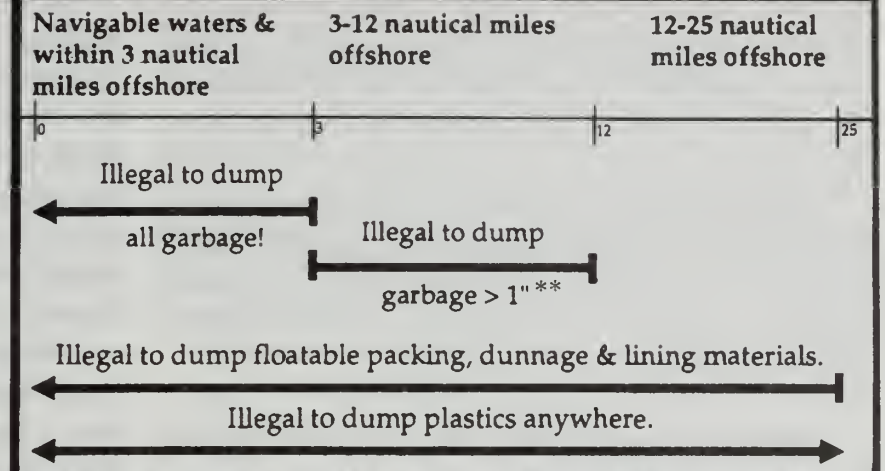
GARBAGE DUMPING RESTRICTIONS

Under Federal law, it is illegal to discharge plastic or garbage mixed with plastic into any waters. Regional, state or local regulations may also apply. All discharge of garbage is prohibited in the Great Lakes and their connecting or tributary waters.

Violators are subject to substantial civil penalties and/or criminal sanctions, including fines and imprisonment.

United States Coast Guard

Center for Marine Conservation


Navigable waters & within 3 nautical miles offshore
3-12 nautical miles offshore
12-25 nautical miles offshore
0
3
12
25
Illegal to dump all garbage!
Illegal to dump garbage > 1" **
Illegal to dump floatable packing, dunnage & lining materials.
Illegal to dump plastics anywhere.

See a marine pollution violation? Record all details of vessel, location and garbage thrown overboard and call the National Response Center at 1-800-424-8802 or your local Coast Guard office by phone or VHF radio, channel 16.

* Artwork courtesy of Center for Marine Conservation

** Pieces in excess of one square inch

The sumps of oil lubricated machinery or the contents of oil filters, strainers, or purifiers must not be emptied into the bilge of any U. S. vessel.

You must also help ensure that others obey the law. You are encouraged to report any polluting discharge you see to the nearest U.S. Coast Guard office. Report its location, source, size, color, substance, and the time you saw it. Do not take samples of any chemical discharge. If you are uncertain of what the discharge is, keep flames away. Avoid physical contact and inhalation of vapors. The Coast Guard oil spill and pollution telephone number is 1-800-424-8802

Plastics and Garbage. On July 31, 1990, a new federal regulation went into effect. It applies to *all* vessels. Vessels 26 feet or more in length must post one or more nine by four inch placards. These must list all at-sea garbage restrictions as in table 2-6. Place them in the cockpit, galley, or other areas where people on board gather. A boat 40 feet and over with a galley and berths must have a written trash disposal plan, and name the person in charge of the plan.

It is illegal for any vessel to dump plastic trash anywhere in the oceans or in the navigable waters of the United States. Plastic includes, among other things: plastic bags, Styrofoam cups and lids, six pack holders, bottles, caps, buckets, shoes, milk jugs, egg cartons, stirrers, straws, synthetic fishing nets, ropes, lines, *and* "bio- or photodegradable" plastics.

You need to know what the terms in the regulation mean. On recreational boats, **GARBAGE** includes all kinds of food. It also includes maintenance waste such as oil and grease, and domestic waste, which we usually call "trash." It does not include fresh fish or fish parts. *On the Great Lakes and their connecting or tributary waters, the discharge of ALL garbage is prohibited.*

DISHWATER is the liquid residue from manual or automatic dishwashers. Its definition assumes that the dishes and cooking utensils have been pre-cleaned to remove food particles that would interfere with the operation of automatic dishwashers. If they haven't been pre-cleaned, the water they are washed in is garbage.

GRAYWATER is water from a dishwasher, shower, laundry, bath or washbasin. It does not include waste from toilets or urinals. It is not classed as garbage.

DUNNAGE is cargo associated waste. It includes lining and packing materials that float. It also includes the containers and boxes your fish bait came in.

If a recreational boating facility can provide wharfage or other services for 10 or more vessels, it must have means of garbage disposal. Facilities include marinas, yacht clubs, and attended launching ramps. Vessels must be conducting business with the facility or marina to qualify for the service. The terminal or marina can charge reasonable fees for its service.

Violators of this regulation are liable for a civil penalty not to exceed $25,000 for each violation. Criminal penalties, not to exceed $50,000 and/or imprisonment up to five years, may be imposed.

Speed Regulations. Most speed regulations are local ordinances or state laws or regulations. Federal regulations, require that you proceed at a safe speed so you can take proper and effective action to avoid collision. You must be able to stop in a distance appropriate to the circumstances and conditions. To determine safe speed, things such as visibility, traffic density, maneuverability of your vessel, and wind and sea state are considered.

State and Local Regulations. You are responsible for obeying all state and local regulations. Their purpose is to protect you and other people. They vary from location to location but include things such as: (1) kill switch that shuts off the engine if the operator falls away from the helm or overboard, (2) speed and wake regulations, (3) operator's license, (4) rear view mirrors and observers if towing skiers, (5) age for operating or renting boats, and (6) laws regulating the operation of personal watercraft. You can consult your local police department or marine patrol for further information.

SUBSTANCE ABUSE

Recreational boating is an activity that people engage in for fun. For many people, their entire social lives revolve around boats. Some of these social activities include consumption of alcohol and other mood altering substances.

Unfortunately, as with automobiles, alcohol is a contributing factor in many boating accidents and deaths. Legal issues aside, drugs and alcohol have no place on a boat. Operating a boat is usually a simple, relaxed affair. But a single wrong choice, a single moment of inattention can turn an afternoon outing into a disaster. The sea can be very unforgiving.

Nearly one thousand people a year die in boating accidents. A large number of these deaths involve alcohol, used either by the victim or by another person involved in the incident. Add to this number the thousands who are injured each year. The result is a frightening picture of needless suffering and expense directly related to the use of alcohol and other drugs.

Boating, pleasant as it can be, is a stressful activity. After only a few hours on the water, a normal, healthy boat operator's perceptions and judgment are impaired even *without* alcohol or drugs. Unaccustomed exposure to fresh air, glare, ultraviolet light, motion, and noise can impair you as much as if you were legally intoxicated.

If you doubt that these factors can alter behavior, spend a couple of hours at a launching ramp. See how otherwise rational people try to load their boats on trailers. Add a few drinks or substance use and you have an explosive situation.

On a boat, if you fall overboard and are lucky enough to escape the propeller, you may find your situation deteriorating rapidly. The aftermath can be much worse than the accident.

If you have been drinking or using drugs your chances of surviving an accident are greatly reduced. Alcohol and depressant drugs lower your resistance to hypothermia, a serious medical problem. Intoxicated people who fall into the water are much more likely than sober ones to become disoriented. They may swim downward rather than toward the surface. Just when good judgment and mental sharpness are needed most, they are muddled by the intoxicants.

Illegal drugs are just that—illegal. If you or guests on your boat are found in possession of or using illegal drugs, the results may be devastating for all involved. At the least, under the zero tolerance rule, you stand to lose your boat and other personal assets. You may also lose your freedom.

Even legal drugs may impair physical ability and judgment. Antihistamines, "seasickness" pills, sedatives, tranquilizers, etc. can all affect you adversely.

BOATING ACCIDENT REPORTS

The operator of a vessel involved in an on-the-water accident must stop, render assistance, and offer identification. If a person disappears from a vessel or a death occurs, local authorities must be notified immediately.

A written accident report is required within 48 hours if a person dies, disappears from a vessel, or requires treatment beyond first aid. A written report must be filed within 10 days if a vessel is lost or damage to it or other property exceeds $500. File the report forms with the state authorities who have jurisdiction over the waters on which the accident happened. Were it to occur in Alaska, get form CG-3865 from your nearest Coast Guard Marine Safety Office, Marine Inspection Office, or Marine Safety Detachment. Accident reports are used to compile safety data. Information contained in them is not made public.

COURTESY MARINE EXAMINATIONS

One of the roles of the Coast Guard Auxiliary is to promote recreational boating safety. This is why we offer this course. It's also why we conduct thousands of Courtesy Marine Examinations each year. The Auxiliarists who do these examinations are well-trained and knowledgeable in the field.

These examinations are free and done only at the consent of boat owners. To pass the examination, a vessel must satisfy federal equipment requirements and certain additional requirements of the Auxiliary. Your instructors can tell you how to get your vessel examined.

If your vessel does not pass the Courtesy Marine Examination, no report of the failure is made. Instead, you will be told what you need to correct the deficiencies. The examiner will return at your convenience to redo the examination.

If your vessel qualifies, you will be awarded a safety decal. The decal does not carry any special privileges. It attests to your interest in boating safety. Your instructor can tell you how to make arrangements for an examination.

A Reminder:

This chapter covers only the federal regulations with which you must comply. You must also comply with all applicable state and local laws and regulations.

Fig. 2-25. Grandpa is able to enjoy an afternoon of pleasure boating, knowing that his granddaughter is wearing a life jacket.

3

Trailering Your Boat

In chapter 1 you selected your boat. Then, in chapter 2 you learned how to equip it. In this chapter, you will learn how to get it to where you will use it.

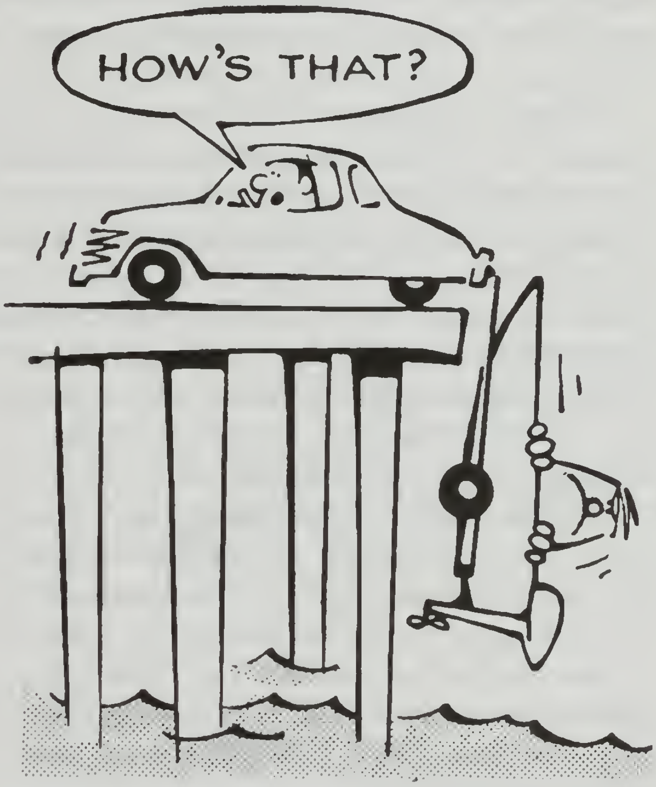
The place where you keep your boat may limit its use. The average small sailing cruiser goes about four knots (4.6 miles per hour). Ten hours of cruising and you are only a few miles from where you started.

Maybe you will put your boat in a marina. If you do, you probably will cruise in its area.

But you may not be able to find space in a convenient marina. Also, its hours may not be convenient for you. Too, the price of storage may be beyond your means. So where does this leave you?

Trailering a boat has its good and bad points. If your boat is trailerable, you can start your vacation many miles from your usual cruising area. You can visit places you don't normally see. Also, you can avoid the costs and hazards of marinas. At season's end, you can store your boat at home where you can work on it through the winter months.

This picture has its negative side. The potential problems in trailering are many; this chapter deals with the most common ones. On the other hand, boat trailering has become increasingly popular in recent years. Over 95 percent of the recreational boats in the United States are trailerable.



LEGAL CONSIDERATIONS

There are several legal considerations that affect boat trailering.

Width

One of the few absolute limits in trailering a boat is its width. Without a special permit, the widest boat you can trail on most state roads is eight feet. On interstate highways, on some access roads, and on federally supported highways with 12 foot lanes, the maximum width is 8.5 feet. These widths include both the boat and the trailer.

The width limitation indirectly limits the length of your boat. Practically, a boat with an eight foot beam will be less than 25 feet long.

Brakes

Legal requirements for brakes vary from state to state. The American Boat & Yacht Council recommends brakes if your trailer is designed for a gross weight of 1500 or more pounds.

There are three legal brake systems: electrical, hydraulic (surge), and air. Your trailer's brakes should operate automatically when you apply your car's brakes. They should continue to operate even if the trailer separates from your car.

SURGE BRAKES work from your trailer's momentum. When you apply your car's brakes, the trailer surges forward and applies its brakes through a closed hydraulic system. If you have surge brakes, be sure the brake cable or chain from the trailer to the car is shorter than the safety chains. If the trailer breaks loose, this cable or chain sets the brakes before it parts.

Lights

Lights may be required on trailers in your state. Some states do not require lights if the tail, turn, and stop lights of the automobile are not obscured by the trailer or the boat. Other states require trailers to have sidelights, tail lights, stop lights, and turning signals under all conditions. Check with your automobile registration authority.

Fig. 3-1. A Surge Brake

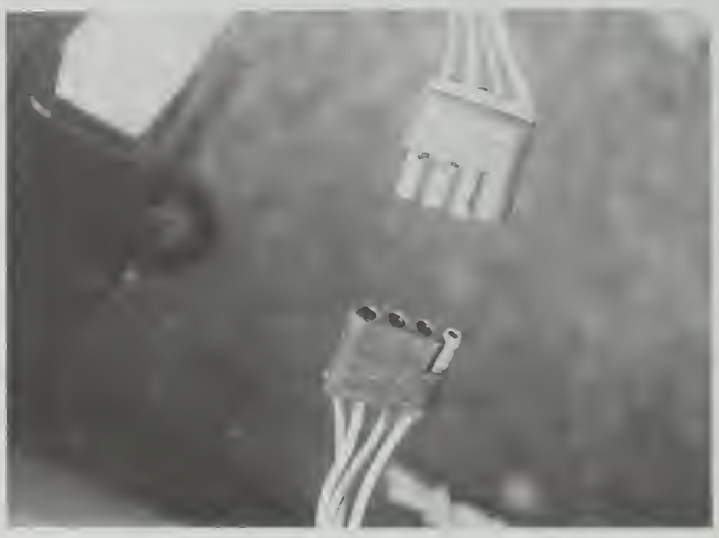


Fig. 3-2. Typical Electrical Connector

Pay special attention to the plug and socket that connect your car's lighting system to the trailer's. The wiring should be under no stress. It should be as weatherproof as possible. It should not sag or loop so it can catch on anything. Neither should it drag along the road. Use stranded wire. It reduces vibration damage. A good ground is necessary, so you may need a ground wire between your car and the trailer. The most frequent cause of trailer light failure is a poor ground.

You may want to add reflectors and taillights on your boat or trailer beyond those required by law. They increase safety at night. You may also want a heavy duty flasher to control your turn signals when towing. A normal flasher under a heavy electrical load operates too fast. If you have a heavy duty flasher, though, you will not know if you have a burned-out turn signal bulb. The flash inside the car will continue to show. Check your bulbs from time to time. Flashers are easy to install.

A vehicle with separate turn and brake lights needs an adaptor to match the car's lights to the trailer's.

Licenses

Most states require licenses for trailers. Check with your local authorities.

Mirrors

Your state may require outside rear view mirrors if your view is obscured. Even if they are not required, consider getting them.

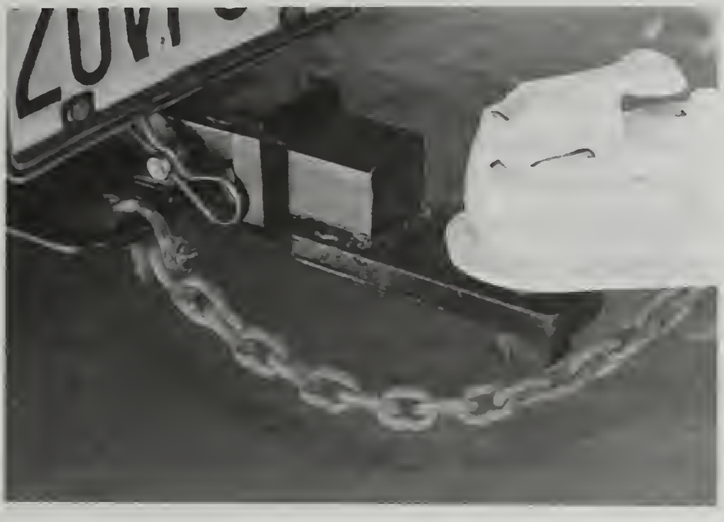


Fig. 3-3. Safety Chains Attached

Safety Chains

Safety chains are a legal requirement in most states. They run from the tongue of the trailer to the towing hitch. Cross the chains under the hitch to form a cradle and secure them to the hitch. The chains should be just long enough to permit free turning. If the coupler fails, the cradle may keep the tongue from hitting the pavement and digging in. If it digs in, your trailer can cartwheel over the trunk of your car.

If the chains have S-hooks, pass them through the eyes in the hitch from underneath. They will be less apt to jump out. Better still, use a **SHACKLE** and wire or snap hooks as shown in figure 3-3. These will not jiggle loose. If you use S-hooks, fasten them on with a piece of wire.

Other Legal Requirements

There are other legal requirements such as the type of trailer hitch you may use. These are discussed in the sections which follow.

PRACTICAL CONSIDERATIONS

In trailering your boat, you should be guided by several practical considerations.

Hull Shape

Your boat's hull shape is a major factor in its trailering. The ideal hull from a trailering point of view, is flat-bottomed, gently rounded, or "V" shaped. For launching from a ramp these shapes are almost mandatory. For launching from a beach, flat-bottomed or gently rounded hulls are most desirable. Boats with unusual hull shapes, especially sailboats, pose special launching problems. Whatever the hull shape, support it evenly on the trailer.

You should consider the problem of fitting your boat to a trailer before buying the boat. Fortunately, most small boat designers had standard brands of trailers in mind when they designed their hulls. Ask your dealer.

You may also want to keep launching problems in mind when you buy your boat. Considering the size and shape of the boat, are there facilities for launching it where you probably will use it? For example, large boats and sailboats are difficult to launch from a beach. Sailboats are launched easiest from a lift. Is the water deep enough at the launch site that a particular boat can be launched?

Selecting Your Trailer

There are also important considerations in selecting your trailer.

Your Trailer's Size

A trailer's class depends on its weight and the weight of its load. When considering the load, remember the weight you will add to the boat. Include the weight of the gasoline, trolling motor, equipment, gear, etc. Trailer sizes are given in table 3-1.

Table 3-1

Trailer Classes	
Class	Gross Weight of Trailer and Load
1	Not to exceed 2000 pounds
2	2001 pounds through 3500 pounds
3	3501 pounds through 5000 pounds
4	Over 5000 pounds

Federal law requires that trailers show their **GROSS VEHICLE WEIGHT RATING** (GVWR). The GVWR is the weight of the trailer and its load. Add the weight of the boat, its contents, and its motor to that of the trailer. If the sum is within 15 percent of the GVWR of the trailer, select the next larger size. On multi-axle trailers, the combined **Gross Axle Weight Rating** (GAWR) of all axles must be at least equal to the GVWR.

If you are planning to pull a load of 4,000 pounds or more, you will want a multi-axle, tandem trailer. Such trailers have four wheels. You will also need a special towing vehicle.

Types of Trailers

There are three types of boat trailers in common use.

Skid Trailer. **SKID TYPE TRAILERS** have carpet covered boards, usually 2 x 4s. The boat skids along these when you launch or retrieve it. The simplest type has only two skids. It is used for small boats with flat or slightly rounded bottoms. Large skid trailers have multiple skids. Fit these skids to your boat to offer maximum support to its hull.

Boat hulls can sag or warp if stored on trailers that are not adjusted to give them maximum support. This can cause serious problems such as poor engine alignment, broken **BULKHEADS** and broken stringers. Poor engine alignment on a stern drive (I/O) or inboard engine can have serious results.

The main support from the trailer should be along your boat's keel. The turn of the bilge, especially where interior weights are concentrated, and the transom are also important points to support. Concentrated weight may be at the fuel tanks, holding tanks, and engines. Remember, when you adjust one support, there is a matching part on the opposite side.

It is a good idea to have your dealer fit the trailer to your boat. Adjusting skids and rollers with a boat on the trailer is next to impossible. Your dealer will have a hoist to raise and lower your boat while fitting it to its trailer. Check the trailer's fitting bolts from time to time. Are they tight? Take appropriate wrenches with you when you are towing the boat. Sooner or later some of the bolts will loosen.

Float-On Trailer. **FLOAT-ON TRAILERS** are used with boats more than 20 feet long. They may have skids or rollers. In use, they are immersed in the water and the boat is floated off or on. These trailers are easy to use but they may have problems. Brakes immersed in water will not "hold" until they dry out. Iron or steel immersed in salt water will rust even if washed down frequently. Bearings can get wet and seize. Bearings immersed in salt water must be cleaned and repacked after each use.

Roller Supporting Trailer. The third type of trailer is one with a roller supporting system. The rollers give maximum support to the vessel and aid in launching or retrieving it. Some of these trailers are called **TILT TRAILERS**. They unlock somewhere along their tongues and tilt up or down. When you launch your boat, you release a pin and the boat tips back and slides into the water.

To retrieve your boat, tilt the trailer. As you pull the boat up on the trailer, the trailer goes back to its original position and locks shut. If your trailer has this mechanism, check to see that it is secure before pulling it up the ramp.

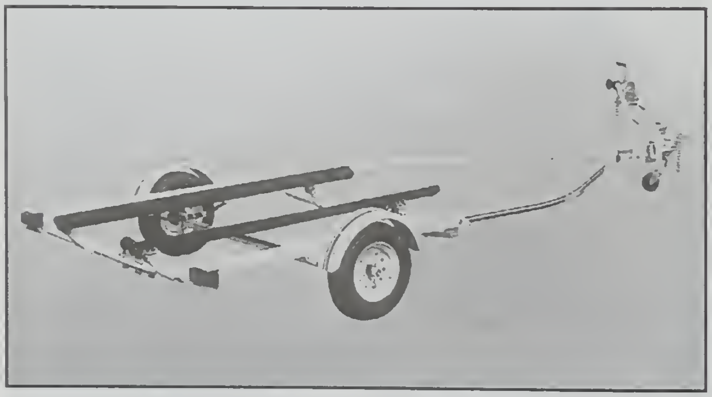


Fig. 3-4. Skid-type Trailer
(Courtesy Calkins)

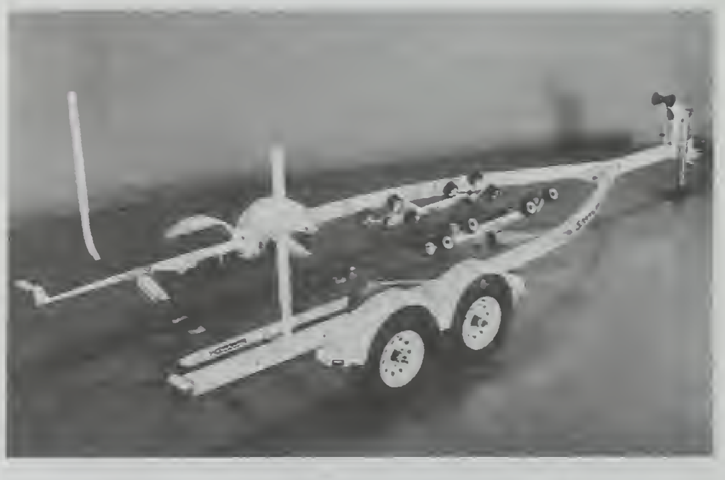


Fig. 3-5. Trailer with Rollers and Skids
(Courtesy of Midwest Industries, Inc.)

One advantage of a tilt trailer is that you do not get your automobile close to the water. With a float-on trailer you may back your car's tailpipe into the water; if the engine stalls, water may enter it.

Tilt trailers have another advantage. You do not have to back their wheels into the water. This is helpful where the ramp stops at the water's edge as it does in ramps at deep water launching sites. It is also good when launching in salt water. Wheel rims immersed in salt water rust. When rims rust, tubeless tires will not hold air.

Care of Your Trailer

Your trailer will last longer and serve you better if you care for it properly.

Wheel Bearings

Tilt trailers have still another advantage. They keep wheel bearings out of the water. Bearings immersed in water, especially salt water, soon seize up. When they do, they are useless. If they seize up on the road, they create a dangerous situation. A device called a wheel bearing protector is designed to keep water out of your bearings. It is spring-loaded with a fitting similar to those used for lubricating automobiles (zerk fitting). With it, you can fill the hub with grease from a gun. Even so, some water may enter the hub. It makes good sense to use a good quality marine-type wheel bearing grease on your bearings and to keep the hubs out of the water. Keep them out even if you have wheel bearing protectors.

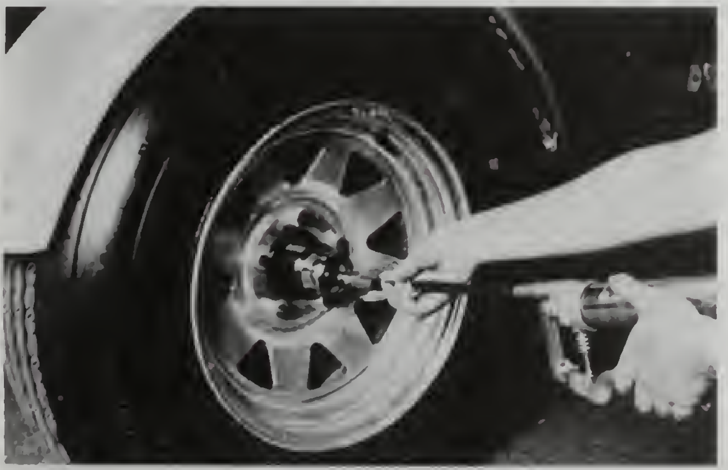


Fig. 3-6. Lubricating a Wheel Bearing Protector
(Courtesy Aqua Power)

When you ride down the highway, even well-lubricated bearings warm up. Sometimes they get hot. When immersed in cold water, a partial vacuum is created and water rushes into the wheel hubs. If you must immerse your bearings, let them cool off before you do it. Always carry spare bearings, grease, and tools for replacing the bearings when you are trailering on a highway. It may be impossible on a Sunday afternoon to find bearings to fit your trailer.

Trailer Lights

If possible, mount your trailer lights on a removable board. Then remove it before backing your trailer to the water. Boards such as these usually clamp on your boat's transom. No lighting system can tolerate repeated immersion, even lights that supposedly keep water out. "Waterproof" trailer lights are seldom so. This goes double for salt water.

If you do not have your trailer lights on a removable board, at least disconnect them before backing down a ramp. Applying your brakes heats the bulbs. They may crack when they hit the water.

Always carry spare bulbs with you. Lights on trailers receive rougher treatment than lights on automobiles. If your lights fail and your bulbs seem to be good, polish their terminals with a piece of fine sandpaper. A small amount of corrosion will keep bulbs from lighting. The same thing applies to your boat's lights.

Always carry highway safety flares, a trouble flag, and trouble lights for use along the road. But don't even think of putting highway flares into your boat. They are a fire hazard aboard a boat.

Trailer Tires

Trailer tires require special attention. The chances are they will die of old age before their treads are gone. This comes partially from the conditions under which trailers are stored. It comes, also, from overheating. The number one enemy of tires is heat. Watch for spider-web cracking on the sidewalls. This is a sign of old age.

Tire Pressure and Tire Life. The portion of a tire immediately above the road surface is continually flexing. Trailer tires are often smaller than those on automobiles. This means that they spin and flex many more times per mile than your car's tires do. When tires flex, they get hot. Eventually, they blow.

You can reduce premature tire death by keeping your trailer tires properly inflated. Follow the manufacturer's recommendation. You will notice that small trailer tires carry high air pressures. Pressures of 60 pounds per square inch are common. This reduces flexing and heating.

You will probably find the correct pressure for your tires stamped on their sidewalls. Inflate them correctly. Above all, do not underinflate them. Carry a pressure gauge with you and check the pressures often. But be careful. Each time you check a tire's pressure, some air escapes. You don't have to let much air out of a small tire to reduce its pressure significantly.

You will also need to inflate your auto's tires for the added load of the boat and trailer. Your owner's manual will tell you the correct pressure for your tires when carrying a heavy load.

You may also find the maximum load *capacity* stamped on your trailer tires. Don't overload them.

Changing a Tire. Regardless of how good you care for your trailer tires, sooner or later you may have a blow-out. Chances are that this will occur on a weekend when the stores are closed. That's when most people trailer their boats. And the chances are that it will occur out in the country. Be prepared! Always carry a mounted spare tire and wheel. Check to see that it is properly inflated.

A spare tire will not do you any good if you do not have a lug wrench that fits your trailer's lugs. Get one, and make certain that you can loosen the lugs with it. The lugs were probably put on with a pneumatic wrench and may be more than "hand-tight."

You may still be in trouble. Do you have a jack that will fit under the axle of your trailer when it has a flat tire? In most cases, your car's jack will not work on your trailer. Buy a special jack and take it with you. Don't forget its handle.

And you may have another problem if the shoulder of the road is soft and will not support a jack. Carry a strong board or something else to give the jack support on a soft shoulder.

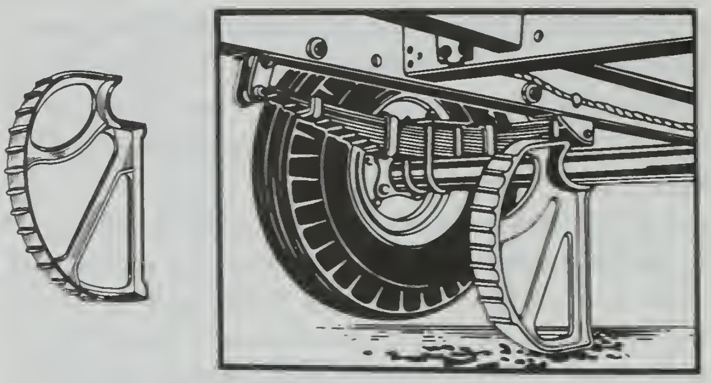


Fig. 3-7. Jack Specifically Designed For Trailers
(Courtesy Moeller Marine Products)

A scissors type jack will probably fit your purpose. But check it out. Can it go low enough to fit under your trailer's axle if you have a flat tire and if you must use the board?

If you have a flat tire, drive completely off the road, if possible, but do not drive onto soft ground. Get all of your tools together, including the mounted spare tire. Check to see that you will not have a problem in jacking the trailer. Then, before you jack up the trailer, use the wrench to loosen the lugs slightly. You will find it impossible to loosen them when the wheel is up in the air. Jack up the trailer, put on the new tire, tighten the lugs as far as you can, and lower the trailer. Then, make certain that the lugs are tightened securely.

If you can't get your jack under the trailer's axle for any reason, consider putting the spare tire flat on the ground in front of the blown tire. Then pull the trailer up on the spare with your car. You should now have enough room to put the jack under the axle. After you have jacked it up, you can remove the spare tire.

Other Practical Considerations

There are other factors you must consider for your safety and the protection of your load.

Fire Extinguishers

You should have a fire extinguisher readily available when trailering. Overheated bearings can catch fire. Someone might carelessly throw a cigarette in your boat and cause a fire. If your boat is covered with a tarpaulin, a cigarette could land on it and you would not be able to get to your boat's extinguisher. There are many ways in which a fire can start.

Mount an extinguisher on the winch stem. If you don't want it there put it inside your car or in your car's trunk. Wherever it is, be certain that it is readily accessible.

Winches

A winch is an invaluable aid when retrieving a boat. Two types are available. A manually operated one is usually standard equipment. An electrically powered winch is optional and is recommended for boats longer than 16 feet. This winch operates off your automobile battery and usually requires special wiring. The cables to complete this wiring are usually packed with a new winch.

The line on the winch is usually either polypropylene or steel wire. Sometimes it is a web belt. If you have an electric winch, the line will be steel wire. Steel wire is also recommended for any vessel 16 or more feet in length. Be careful with polypropylene. It deteriorates in sunlight and may not hold your boat. Nylon is not used on winches since it stretches too much.

The primary point of attachment of the boat to the trailer is at the winch. Be certain that your winch has a good anti-reverse mechanism and keep it in good working order. But don't trust it. After your boat is on the trailer, tie the towing eye to the stem of the winch. The usual ratchet type anti-reverse mechanism is small enough that you don't want to trust your boat's security to it.

If you are using a manually operated winch be careful when you launch your boat. As the boat slides off the trailer, the winch handle will turn forcefully. It can seriously injure your hand or arm.

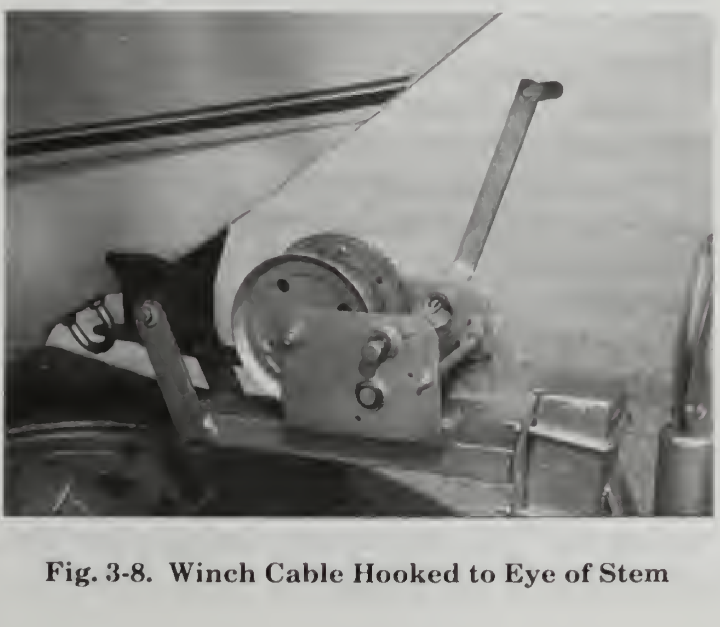


Fig. 3-8. Winch Cable Hooked to Eye of Stem

Tie-Downs

The boat should also be secured firmly to the trailer. Tie a line from the towing eye of the boat to the *tongue* of the trailer. Should the winch stem come loose, the bow of the boat will still be secure. **TIE-DOWNS** should also be placed at or near the stern of the boat.

If there are **LIFTING RINGS** on the transom, tie lines from each ring to the trailer. If you can't get these lines tight enough, consider buying straps made for this purpose.

Tie-down straps made of webbing are available. These stretch across the boat and hook to either side of the trailer. If you use straps, cushion under them to keep from harming your varnish or gel coat.

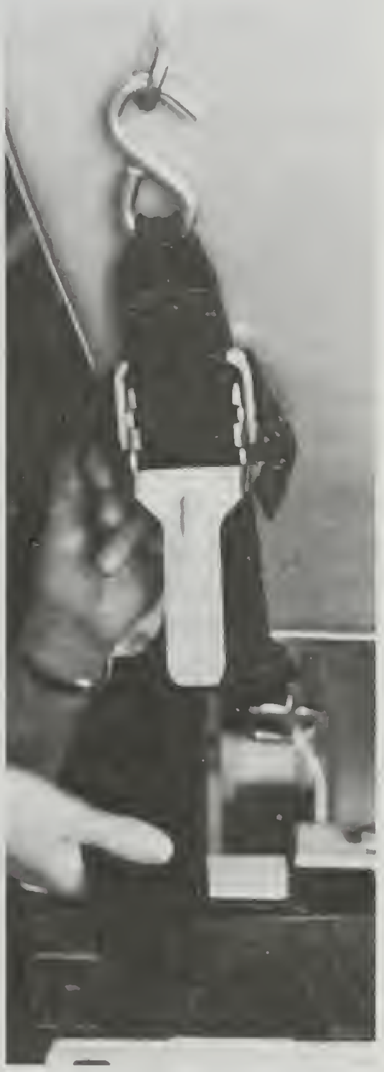


Fig. 3-9. A Transom Tie Down

(Courtesy EPCO)

Straps that reach across the vessel are acceptable for small boats. Tie larger ones down at the stern. Should you be in an accident, you will want the boat to stop when you do!

Rust and Breakdowns

Iron and steel are subject to rusting and, if exposed to salt water or air, they are subject to heavy rusting. Touch up rust spots as they occur. Sand them off with emery cloth and spray them with "galvanize" paint.

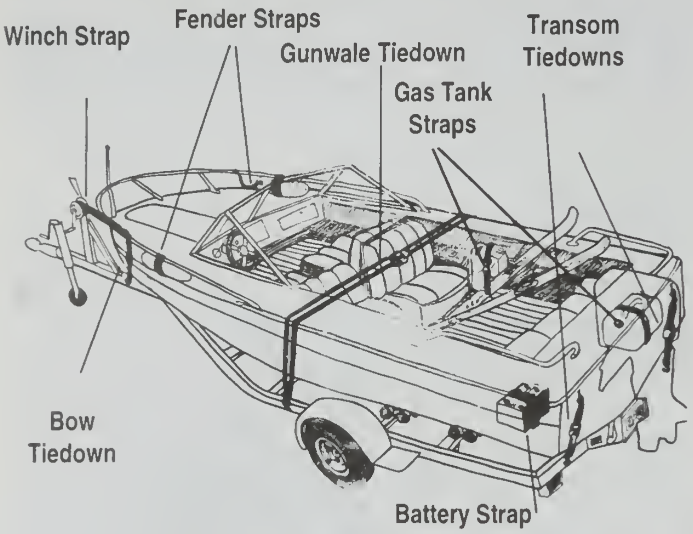


Fig. 3-10. Tie Downs Add to the Safety Factor.

Pay special attention to the springs and axles on your trailer. Keep them rust free. If they become rusted, have the springs replaced or the axles strengthened. Both are subject to heavy strains on the highway and may break down. If they do, they may cause serious damage to you, your auto, and your boat. As with other aspects of trailering, an ounce of prevention is worth it.

THE TOWING VEHICLE

Your automobile is an important part of the towing package. It was not designed, however, to trailer a boat. If it has front-wheel drive, it is even less capable of trailering.

To steer properly, automobiles must have enough weight on their front axles. For front-wheel drive automobiles, both steering *and* traction depend on the weight on the front axle. But when you add weight to the rear of your auto, the front end lifts. This makes it difficult to control. It also affects traction for front-wheel drive cars. It affects the focus of lights and the driver's vision on all automobiles. It also places a strain on the auto's rear tires, shocks, and springs.

The typical front-wheel drive car has a gross weight of about 2800 pounds. Its owner's manual says that it should not pull a trailer weighing more than 885 pounds unless the trailer has brakes. With trailer brakes and a manual transmission, it can pull 2200 pounds up hills having less than a 12 percent slope. It can pull the same 2200 pounds up a 16 percent slope if it has an automatic transmission.

Your car must have enough power to merge safely with highway traffic when towing its maximum load. It must also be able to climb the hills you will meet without loss of speed. This usually means that you should get the largest engine available for your car.

Towing Package

Unless your vehicle is specially equipped, you should not tow a trailer that weighs more than it does. Many manufacturers sell towing packages. These are not expensive if bought when you order your car. If ordered later, their cost may be prohibitive. Towing packages include several modifications for your car.

Cooling

When your car is pulling your boat, it uses more energy than usual. This means that it produces more heat. You will need a heavy-duty, high-capacity radiator. It will have more core tubes to aid heat release. It may also have a special fan shroud. A thermostat controlled spraying unit is also available. It sprays cool water on the radiator if the coolant temperature goes too high.

Transmission

Towing a trailer places an extra load on your car's transmission. This may thin out its fluid and damage it. A small radiator to cool the transmission fluid is available. You should be alert to transmission leaks, slippage, or rough shifting. Any of these may mean problems.

Brakes

If your car has a towing option it has oversized brake drums and/or special heavy duty brake linings. Standard auto brakes are too small for towing all but very light trailers. Brakes should have premium linings. This is essential for rear wheel brakes.

Suspension System

One hundred pounds of tongue weight has the same effect as putting 400 pounds in the trunk of your car. To avoid sagging and "bottoming out," you need heavy-duty springs and extra large or air-adjustable shock absorbers.

These allow your car to ride in a nearly normal attitude. They also improve your visibility and your car's handling.

Other Equipment

The trailering package may contain a larger battery and a larger alternator with which to charge it. The car probably will have oversize tires and a lower gear ratio in its differential.

Trailer Hitches

Three types of trailer hitches are available. The first two of these hold the entire tongue weight of the trailer. The third distributes the load to all four wheels of the towing vehicle.

Bumper Hitch

BUMPER HITCHES are the simplest trailer hitches. They clamp on the bumper of your car. Bumper hitches are rented by many trailer rental places. They are, however, illegal in many states. They offer too little support for a boat trailer. In addition, automobile bumpers are not strong enough to resist and they may twist out of shape. Moreover, the strain of the trailer may damage the hydraulic shock absorbers that connect the bumper to the automobile. If they twist or if they come loose, they present serious problems. Bumper hitches are not recommended.

The "step-bumper" hitch mounted on many light trucks is not considered a bumper hitch. It is acceptable for towing a boat.

Weight-Carrying Hitch

WEIGHT-CARRYING HITCHES are available for most models of automobiles. They bolt to your car's frame and frequently to the floor of its trunk compartment.

This type of hitch usually has stamped on it the total weight it can pull and the weight it can support. The maximum weight on the hitch should not exceed 150 pounds. For many cars it should not be more than 100 pounds. The maximum load this hitch can pull is 2000 pounds. This means that the longest boat that can be trailered with it is less than 16 feet long unless the boat is very light. A 16 foot, hand-laid fiberglass boat may weigh 1600 pounds or more without a motor.

Weight-Distributing Hitch

A **WEIGHT-DISTRIBUTING HITCH** is included in a trailering package. This hitch can also be added to your automobile after delivery. It distributes the weight on your car and makes it more nearly equal on all four of its wheels. The result is better handling, safer operation, and less wear on the towing vehicle. Some weight-distributing hitches come with anti-sway bars that help control trailer sway and further improve control.

Trailer Ball and Coupler

The trailer hitch has a ball to which the trailer coupler is attached. These balls are of several different sizes. The most common are 1-7/8 inches, 2 inches, or 2-5/16 inches in diameter. The 1-7/8 inch ball is used only for very light trailers.

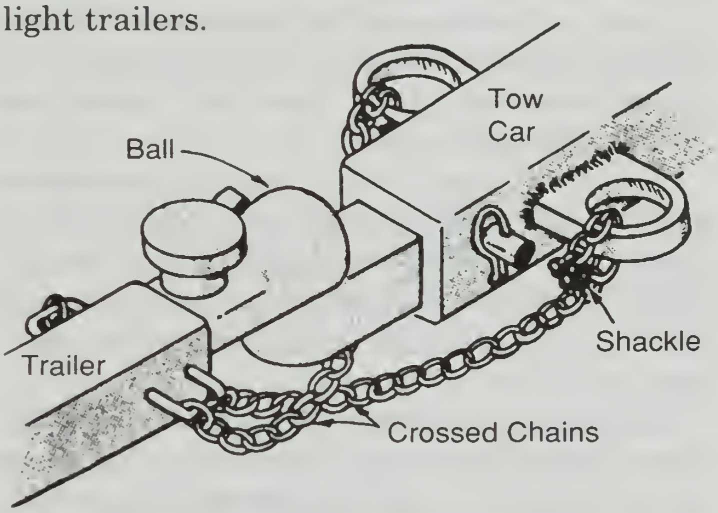


Fig. 3-11. Trailer Hitch

Trailer balls are not interchangeable. Make certain that you are using the correct sized ball for your coupler. A trailer coupler designed for a larger ball may seem to fit on a smaller one. *It is dangerous to do this, though.* The coupler can come loose with disastrous results.

It is sometimes possible to put a coupler on a larger ball than it is designed for. Don't do it. It will bind and the trailer will not track correctly. This means the trailer will not follow the same path as the auto.

The threaded shanks of balls vary in size with the ball. If you use a smaller ball than you should, you are also using an undersized shank that could shear.

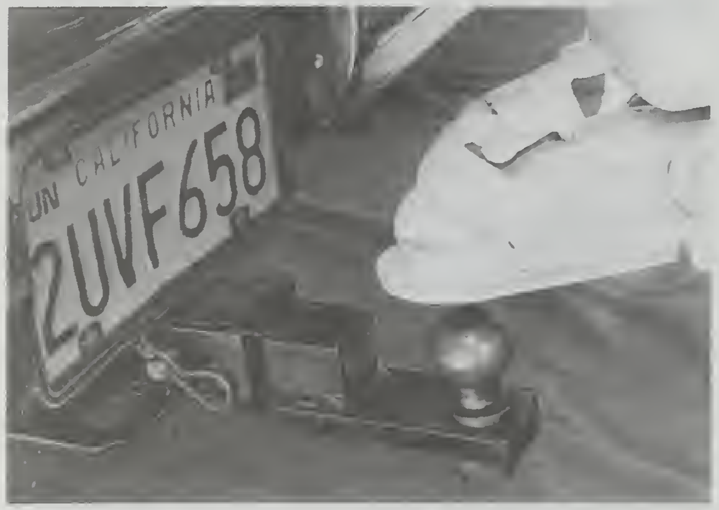


Fig. 3-12. Tongue in Position to Engage Ball

The size of the ball you must use is determined by the size of your trailer's coupler. This, in turn, is determined by the Gross Vehicle Weight Rating (GVWR) of the trailer. All couplers manufactured after 1973 have the GVWR stamped on them.

Carry an extra ball with you and a wrench with which to install it. Wear and turning stresses may force the ball out of roundness. Secure the ball with a lock washer and nut. It is a good idea to grease the ball before coupling the trailer to it.

Couplers are of two types, the latch or the screw type. If you have a latch type, secure it with a padlock or a pin. This will keep it from coming loose. A padlock also protects your trailer against theft. This is an important consideration if you leave your car and trailer at a public ramp. A padlock may keep it from "walking off."

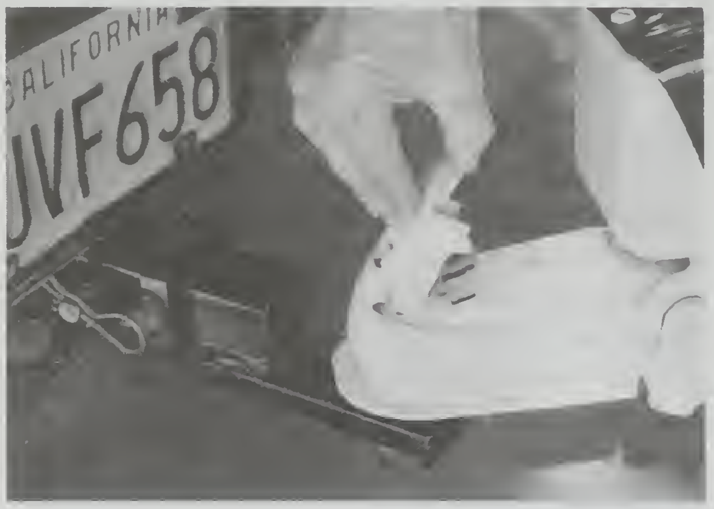


Fig. 3-13. Locking Ball in Cup

BALANCING THE LOAD

Balancing the load on your trailer is an important factor in successful towing. Between *five and seven percent* of the total weight of the tow (boat + motor + contents + trailer) should be on the tongue. If you have more than this, the front end of your car lifts up, the rear squats, and your car is hard to handle. If you have less than this, the trailer is likely to fishtail.

A trailer loaded so it fishtails is unstable and dangerous. You may be unable to control it. The wind from a large truck can cause you to have a serious accident.

For the average passenger car, the tongue weight should not be more than 100 pounds. Any additional weight will overload the car. Work backward from the 100 pounds and use a figure of five percent of the weight on the tongue. You will see that a gross weight of 2000 pounds is the maximum your car should tow. Remember, this 2000 pounds includes the weight of the trailer, boat, motor, and the boat's contents.

To measure tongue weight, load your boat with the gear it usually carries. Then stack a couple of cinder blocks and put your bathroom scales on the stack. On top of this put something to protect the scales. The total height should be the same as the height of the trailer ball above the ground. Now lower the trailer tongue onto the scales.

You can adjust the weight on the tongue in two ways. The simpler one is to move the load inside the boat. If you have too little weight on the tongue, move equipment forward in the boat. If you have too much weight, move equipment astern.

More serious weight adjustments entail moving the boat on the trailer. The winch stems of most trailers can be moved forward or backward on the tongue.

You can determine the gross weight by adding the weight of the trailer, the boat and motor, and equipment. Your dealer can tell you the weight of the trailer, boat, and motor. You can estimate the weight of your equipment.

You can get a more accurate measure by taking the rig to the nearest platform scales. You will find one at a highway weighing station, building supply company, trucking company,

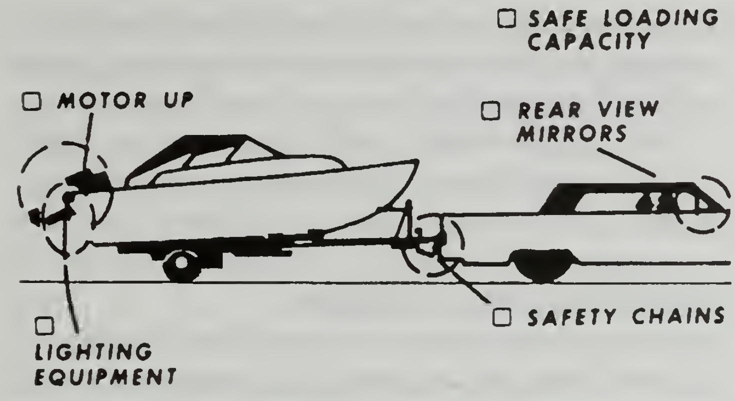


Fig. 3-14. Consider All of the Pieces: Boat, Trailer, and Towing Vehicle

or junkyard. As a last resort, call your local moving company. They always know where scales are located.

If the tongue weight of the trailer is 70 to 75 pounds or more, consider fixing an accessory jack and dolly wheel to it (fig. 3-15). It will be easier to move the boat. You also can use it to raise or lower the tongue to couple it to your car. And you can raise it to its fullest point to allow the boat to drain when it is stored.

HANDLING YOUR TRAILER

If you have never handled a trailer before, take it to a parking lot some Sunday afternoon and practice backing and parking.

On the way to the parking lot, start your car slowly, and take it up through gear changes smoothly and gently. Think twice before you pass another car. If you decide to pass, pick a spot and go. Don't hesitate. When rounding corners, be sure to swing wide enough that you don't hit curbs or other cars waiting in the cross street. When turning, check traffic behind and alongside you. Give others plenty of warning with your turn signal.

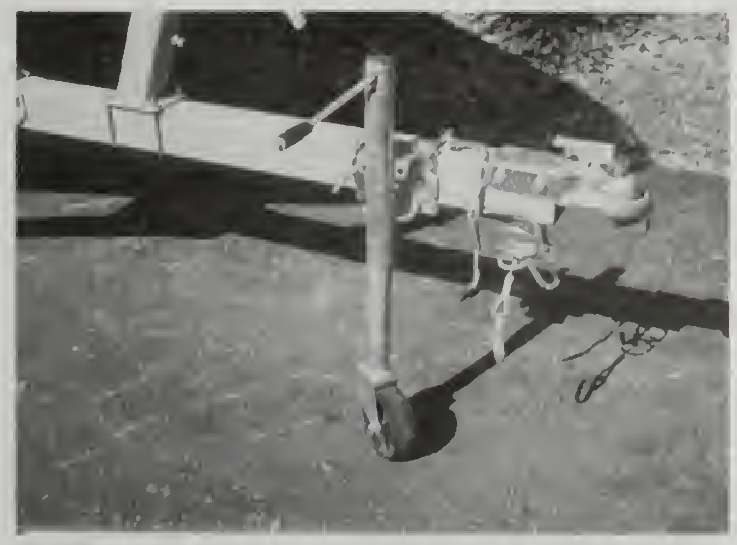


Fig. 3-15. Trailer Tongue, Jack, and Dolly Wheel

Underway, remember that you have a long, heavy, awkward tail behind you. It's easy to forget. You have seen people pulling trailers cut in ahead of you. They are not aware that their car is 20 to 25 feet longer than usual.

Remain sensitive to any unusual sounds. If you notice anything at all out of the ordinary, pull over and check. But don't do it until you have checked to see there is no one alongside. On the highway, check out the entire rig every hour or so. Check the temperature of the wheel hubs and tires by touching them. Check tie-downs, wheel lugs, and trailer bolts. If you are using a heavy duty flasher, check for burned-out bulbs by turning them on and walking around the car and trailer.

At the parking lot, practice turning. Light standards are excellent for learning how to judge your swing at corners. Careful--you don't want to buy one.

The main thing to practice is backing up. This can be difficult, especially if you have a short trailer. In fact, the shorter the trailer, the more difficult it is to back. If your trailer is shorter than your automobile you have a very difficult problem. The secret is to back slowly and don't allow the trailer to get much out of line with the towing vehicle.

It is easier to back if you place your hand on the bottom of the steering wheel instead of its top. Then, turn around and watch were you are going. When you want the trailer to go to the left, keep hold of the wheel and move your hand to the left. To make the trailer go to the right, move your hand to the right.

Work out a set of hand signals with your partner. Have signals for continue, stop, left, and right. On many ramps the driver loses sight of the trailer as it starts down the ramp. A partner is indispensable at this point. Rely on hand signals rather than oral directions.

The one place you might want to use a bumper hitch is at the ramp and on your front bumper. Even here a more permanent hitch is recommended. With such a hitch, you do not have to back down the ramp. This is especially helpful if you are trailering your boat behind a motor home. If your trailer is behind the vehicle, you may not be able to see it. But with a front bumper hitch, your trailer is always visible. A bumper hitch used this way is not subject to the same stresses and strains as one on the rear bumper on the highway. Use it only at a ramp!

PRE-DEPARTURE CHECKS

Some things should be done before the day you go. These pertain to the trailer, the boat and its motor, and the towing vehicle.

Check Your Trailer

The two most important items in a pre-departure check of your trailer are its wheel bearings and the amount of air in its tires. Have a regular schedule of maintenance for the wheel bearings and clean and repack them at regular intervals or after they have been immersed in water. Before departing check the pressure of the air in the trailer's tires.

Assemble the emergency equipment, parts, and tools you will take with you. You might want to make a check list. The list will remind you to inflate your spare tire and take it along. It will remind you of your jack, lug wrench, spare bearings and grease, spare bulbs, spare fuses, wrenches, trouble flag, and trouble lights.

Before setting out, see that items in your boat are secured. Make certain that no one has tossed in last-minute items that can significantly alter your trailer's balance.

Did you grease the ball before coupling? Is the coupler locked? Are electrical connections made and are the lights and electric brakes, if you have them, working? Are your turn signals working? Have you installed the heavy duty flasher?

Have you raised the boat's motor or outdrive? Is it secured in its "up" position with something other than its hydraulic cylinders? Are your tie-downs secure?

If you are trailering a sailboat, did you secure the rigging to the mast? Are the mast and boom padded and tied down? Does the mast protrude beyond the trailer? If so, does it have a red flag on it? If the rudder is removable, did you remove it? If not, did you fasten it in its "up" position? After you put the boat on the trailer, did you lower its **CENTERBOARD** or **DAGGERBOARD** to a secure position on a cross-member of the trailer? (If there is no cross-member that the centerboard or daggerboard can rest on, leave it in its "up" position.)

You might wish to add items to the check list. Whatever you do, check thoroughly before you go.

Check Your Boat's Engine

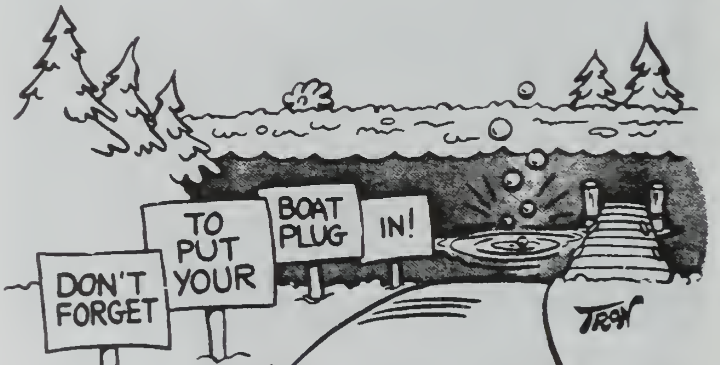
Proper maintenance of your boat's engine is the best thing you can do to help it give trouble-free performance. Study the manual that came with your engine and perform its maintenance schedule religiously. Lubricate it as recommended. Change its spark plugs at proper intervals. Clean its filters on a regular schedule. If it has a hydraulic lift, check its oil reservoir and fill it as necessary.

PREPARING TO LAUNCH

At the ramp, pull to one side and let your bearings cool down. While waiting, prepare your boat for launching. Here, again, it is good to have a checklist. Do everything you can to ready your boat for launching before moving to the ramp. In this way you will hold up other people as little as possible.

If you have a cover on your boat, remove it and store it in your auto. Next, undo your tie-downs and *put in the drain plug.* It is surprising how easy it is to overlook this important item until your boat slowly sinks into the water.

If you are launching a sailboat, you must step its mast. Before doing so, check to see what is overhead. Are there any low power lines? Many municipal ramps were designed for skiffs, not masted vessels. If your mast should fall, are there overhead obstructions it could hit? This is especially important if electrical wires are present. An aluminum mast



and electrified wires are a dangerous mixture. Check, too, to see that you have a clear overhead path from where you are to the ramp and beyond.

If there is a finger pier and if your mast is difficult to raise, you may wish to wait to raise it. It may be easier to do when tied up to the pier.

Check to see that nothing is protruding from the boat to snag on the trailer frame. Is the daggerboard or centerboard pulled all the way into the well and the **PENNANT** lashed down? Is the rudder fastened in the "up" position if it is not removable?

Next, you should undo the trailering support for your outboard or outdrive. Wait until you are in the water to lower either of them. Wait, also, to lower the centerboard or daggerboard and to install the rudder.

Unplug the trailer's lights. Put the connector from the car where it will not get into the water. You are now ready to launch your boat.

LAUNCHING

Some recent videos have shown an operator in a boat with its motor running during launching. This practice is not recommended. Most likely your boat's engine will be cooled by water pumped in from the water into which you are launching. Most outboard motors, stern drives, and inboards pump water by means of **IMPELLERS.** If an impeller runs without water, it will be damaged or destroyed. Even inboard and stern drive engines that have their own coolant depend on water pumped into them. The engine's coolant is cooled in a heat exchanger through which raw water is pumped.

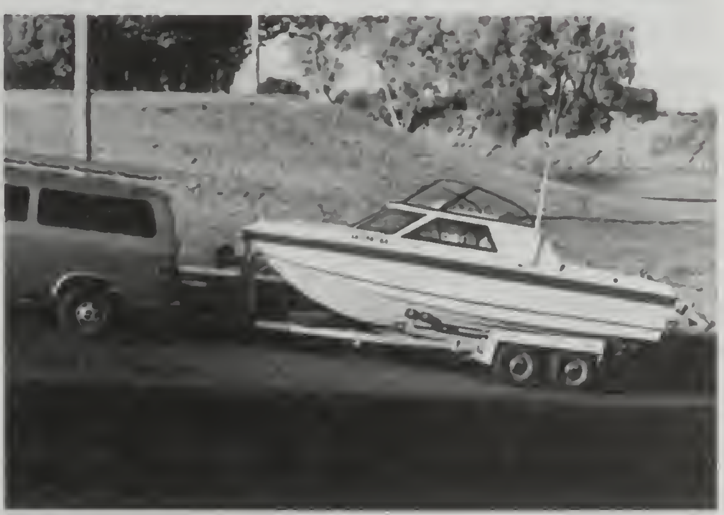


Fig. 3-16. Backing Down the Launch Ramp

The practice of staying in a boat during launching is also not recommended since it is not safe. Boats can tip over when they are launched. No one should be in a boat while it is being launched.

Make sure you have a line or lines from your boat to the shore before launching. If the boat weighs 2500 or more pounds, tie the shore end of one line to some object on shore. The boat may come off the trailer rapidly and may be difficult to control.

Make certain that everyone is out of the way before you back down the ramp. You should know where children are at all times. Back the trailer slowly until the boat's stern is in the water. There is no prize for backing rapidly. If you run off the ramp, you may find there is punishment.

Ramps are dangerous. This is particularly true of ramps in tidal water. Algae grows on them and they can become *extremely* slick. This means it is dangerous to walk on them. It also means that you must be careful not to launch your auto along with your boat. Some ramps are steep. This makes them more dangerous.

Some bodies of water such as impounded lakes, have periodic changes in their water levels. If the level is low, be careful that you do not back your trailer off the end of the ramp. If you do, you have a serious problem.

If at all possible, stay in your car while you launch your boat. In this way you can keep your foot on the brake pedal. This applies the brakes to all four wheels of your car. If you leave the car and use the parking or hand brake, you are applying brakes only to the rear wheels.

If you put an automatic transmission in "park" you have even less braking power than with the parking brake set. In "park" the transmission and the driveshaft lock. However, an automobile has a differential on its rear axle. This allows the rear wheels to turn independently of each other so the car can go around corners. Thus, one wheel or the other can turn at any time. So, now you are sitting on a steep, slippery ramp depending on the braking power of one wheel. With the engine running and the strain of the trailered load, the transmission can slip out of "park." It must be a horrible feeling to watch your boat, trailer, and auto launch themselves. It has been done.

Don't rely heavily on your parking brake. It's not that good. How many times have you backed out of your driveway and then discovered that you hadn't released the brake? In addition to the weight of the car, you have the weight of the trailer, the boat, and its contents to help pull you down the ramp.

If you must leave the car, put the transmission in "park," set the hand brake, and then turn off the engine. If you have a manual transmission, put it in reverse where it has the lowest gear ratio. Carry wheel chocks with you and have someone put them under your wheels before you take your foot off the brake.

After launching, pull the trailer up the ramp to the parking area. Don't take unnecessary time. Others are waiting.

While you are parking your auto, your crew can pull the boat to the pier and tie it up. You are ready to start your boat's engine. First, lower it into the water if it is an outboard. If it is a stern drive, lower its lower unit into the water. Remember, starting the engine without the water intake in the water can damage the impeller in a very short time.

If your motor is an outboard, check its telltale to see if water is coming from it. Remember, though, the water coming from a telltale may be meaningless. You can have insufficient water reaching the engine and still have water coming out of the telltale. On the other hand, you know you have a problem if no water is coming out.

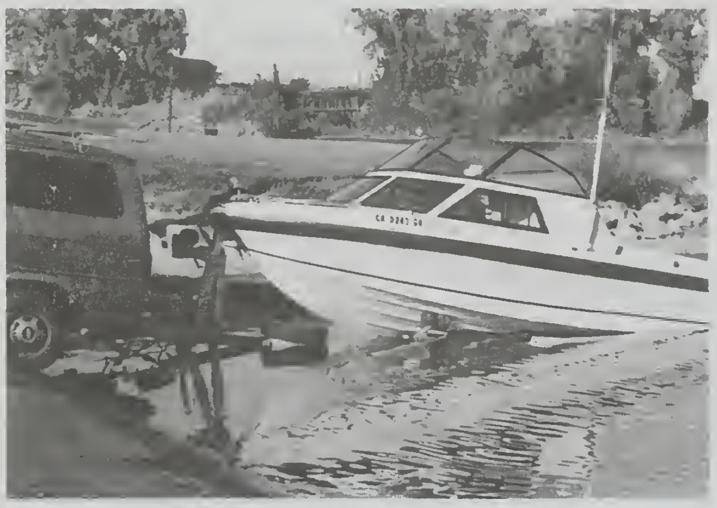


Fig. 3-17. Boat Recovered and On Trailer

RETRIEVING

Recovering a boat is the inverse of launching it. While it is in the water, raise the outdrive or outboard. If it is a sailboat, raise its daggerboard or centerboard and secure it. Remove its rudder or raise it to traveling position. Then get your trailer and back it down the ramp. If your trailer is a float-on type, back it into the water and pull your boat up on it. Connect the winch cable to the towing eye of your boat to secure it.

If your trailer is not a float-on type, connect the winch cable to the towing eye of your boat, and pull it up on the trailer. Make certain that the boat is centered on the trailer. Unless it is very light, you will not be able to move it once it is on the trailer. With the boat firmly on the trailer, drive up the ramp to the parking area. If your boat is a sailboat, lower the mast, and secure it and the boom. Lower its centerboard or daggerboard. Secure the motor or outdrive for trailering. Then, in a leisurely manner, tie everything down that is loose, pull the drain plug, tie the boat down, and replace its cover.

Finally, plug the trailer's electrical connection into the car's outlet. After checking to see that everything is secure, you are ready to roll.

STORING YOUR BOAT AND TRAILER

A few simple measures can extend the life of your boat and trailer. If you are going to store your boat on its trailer for an extended period, jack up the trailer and put cinder blocks under its axles. After you jack it up, check to see that the boat is still evenly supported. Jacking a trailer up can twist it out of shape. Make certain that the whole rig is stable. Strong winds can blow it over. This is especially important if your boat is a sailboat. You may wish to add support shims.

If you remove the wheels, tire life will be extended. Put them inside where they aren't exposed to the sun. Jack up the trailer's tongue so the boat will drain. Of course, you will want to remove the drain plug. You must keep the interior of your boat dry. Otherwise, dry rot will form and ruin any exposed wooden parts. Once dry rot forms, the only way to get rid of it is to remove all affected wood. Since you probably don't know how much wood is exposed below decks, play it safe. Keep it dry. Dry rot forms in the presence of fresh water and is not so likely to form in sea water.

Cover your boat to keep rain water out. But also let air circulate within it to keep it dry. Ready made covers are available or you may have one custom made. Be certain that it is secure and will not blow away. Remember, too, that you must prevent puddling of water. Water weighs about 8.3 pounds per gallon. The weight of collected water stretches the cover. The puddle can then grow larger. Eventually, the cover will split and empty the water into the boat. Support the cover from below.

Before you leave your boat on its trailer for an extended time, check to see that it is firmly supported. If any rollers or skids have come loose, adjust and tighten them.

If you have an inboard or stern drive engine or if you plan to leave your outboard motor on your boat while it is stored, be certain to flush it and then to drain all the water from it. To drain a stern drive or outboard, move the lower unit or the motor to a vertical (operating) position and leave it there until all of the water has drained. An inboard engine can be drained by opening its sea valves.

If you plan to leave your outboard motor attached to the boat during the winter, leave it in its vertical position. Do the same thing for your lower unit. Otherwise, rain water will enter their exhausts and may crack their housings during freezing weather. If you plan to store your boat for an extended period, follow the "laying-up" procedures recommended in your owner's manual.

One final thought. Replace the heavy duty flasher on your car. You will then be able to tell if a bulb burns out.

THEFT PREVENTION

Pleasure boats of all sizes, small outboard motors, radios, compasses, binoculars, and other boating gear are stolen every year. A few simple measures and some forethought would have kept the theft from happening. Some of these things you should do at home. Others apply to the launch site. And still others apply when you return home.

Before You Trailer Your Boat

Permanently mark your Hull Identification Number (HIN) at some hidden location on your boat. It's already marked at its stern and probably in another hidden location. But these numbers can be defaced or altered. If you put the HIN where only you know where it is, you can identify your boat if it is stolen and recovered.

Propellers are expensive items and are often stolen. Inexpensive locks are available to keep them from being removed from your boat.

Mark all of your valuable equipment with an identification number. Most police departments recommend that you use your driver's license number. It is available on most police computers. Most police departments can provide you with an engraving tool for inscribing your ID number on hard surfaces. Soft materials such as cloth covers, sleeping bags, blankets, tents, etc. can be marked with paint, indelible markers, or invisible ink that shows up under ultraviolet light. Visible markings discourage theft. They also help law enforcement authorities recover your things.

Keep an up-to-date inventory of your boating and fishing equipment. This helps you document your loss. Record the name of the equipment, its description, and serial number,

if any. Color photographs or slides help identify your equipment and document its condition and that of your boat.

Make sure that your insurance covers theft of your boat or its equipment. Homeowners' policies may not provide adequate coverage of marine equipment. Marine coverage including your boat, trailer, outboard motor(s), and equipment is usually worth the low premium charged. Shop around for a reliable company and for the lowest premium.

Stolen vessels can be used for illegal purposes. These range from joy riding, which can be dangerous, to use in the drug trade. Your vessel may be stolen for resale to an unsuspecting victim. Do what you can to protect it and prevent its illegal use.

At the Launch Site

Keep your valuables out of sight but don't put them in the glove compartment. Don't leave anything in bags or cartons inside the car. A thief may damage your car to inspect them. Put your gear in the trunk and lock it and the car. It is not difficult to force entry into an automobile trunk. But few thieves will do it just on the chance of finding something of value.

Leave your auto in a well-lighted area if you expect to be gone until after dark. This enhances personal safety and reduces theft. Do not leave your keys in the car.

Use a trailer hitch lock to secure your trailer to your auto. It is difficult to cut loose. If you don't lock your trailer to your auto, it may disappear at the launch site.

Back Home

At home you can secure your trailer by removing a wheel. You can also chain it to a large tree. You can sink a case-hardened steel eye-bolt in concrete and chain your boat to it. Or you can sink a case-hardened steel bolt in concrete and attach a trailer ball to it. You can lock your trailer on this with its hitch lock.

Don't be lulled into a false sense of security simply because you have a good hitch lock. Professional thieves carry coupler devices that can be quickly attached to your trailer.

If possible, store your boat in the backyard or in a garage so it won't be seen by passers-by. If you have to store it in the driveway, don't leave the hitch facing the street.

If you plan to remove your propeller, do it now. You should remove it every few months, anyway, and grease its shaft with a high grade marine-type grease. This keeps the propeller from "freezing" on the shaft. If you remove it, don't forget to put it back on before you go boating the next time. Your boat will run better with it attached.

Remove all valuable portable equipment from your boat. Lock it in a safe place. Don't forget to put it back aboard when you next take your boat out. Above all, don't leave the boat's keys or registration certificate on the boat.

If you have a small outboard motor, remove it from the boat when not in use. This will protect it from the weather as well as from thieves. If you don't remove it, fasten it with a motor lock across its clamps or a case-hardened chain securely fastened to the boat. On larger, less portable, permanently mounted outboards, use special transom retainer bolts. These can

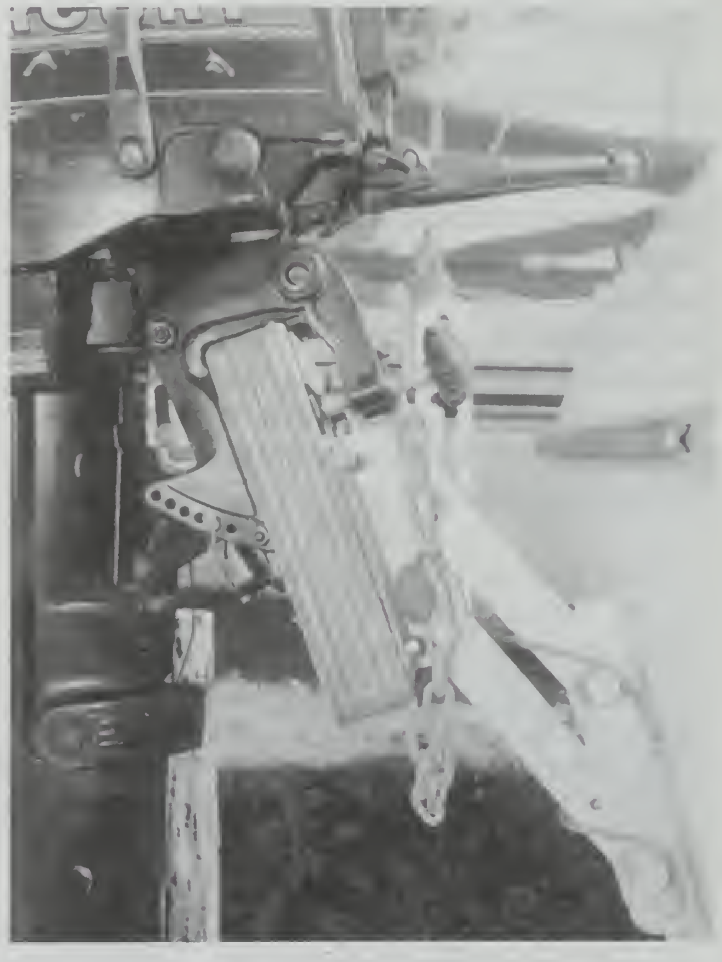


Fig. 3-18. Auxiliary Outboard Chained to Its Mount

be removed only with special sockets.

If you keep your boat at a dock or on a mooring buoy, secure it with a case-hardened chain and lock. Remove portable fuel tanks and a vital engine part such as a distributor rotor or ignition wire(s). A hidden switch in the electrical system between the motor and the ignition switch can be a useful deterrent.

Work with your neighbors and fellow boaters to watch for strangers or suspicious activity. Call your local law enforcement people if you have any doubt whether someone is authorized to work on a boat or trailer. Write down a description of any suspicious people. Get their license numbers or the registration numbers and descriptions of their boats.

ZEBRA MUSSELS

Zebra mussels were accidentally introduced into the Great Lakes region about 1986. Since then, they have spread into the Hudson, Susquehanna, Ohio, Illinois, Tennessee, and Mississippi Rivers and many lakes. The economic damage the mussels have caused by fouling power plants and industrial and public drinking water systems and their damage to boat hulls, engine cooling systems, docks, and navigation buoys underscores the need to prevent their further spread.

There are several steps boaters can take before moving from one body of fresh water to another to keep the mussels from spreading to uninfested waters:

- Paint your boat's hull with an environmentally acceptable antifouling paint,
- Flush your boat's engine, hull, outdrive, and your trailer's frame, preferably with hot water (140°F or hotter),
- Empty your bilge, bait wells, and bait buckets and flush them with water containing chlorine bleach,
- Do not take bait from one body of water to another,

After flushing, allow your boat and trailer to dry at least two to four days in the sun before moving to another body of fresh water. If you do not follow the above precautions, drain your engine, bait wells, and bilge, and allow them to dry for at least two weeks before launching them in a different body of fresh water.

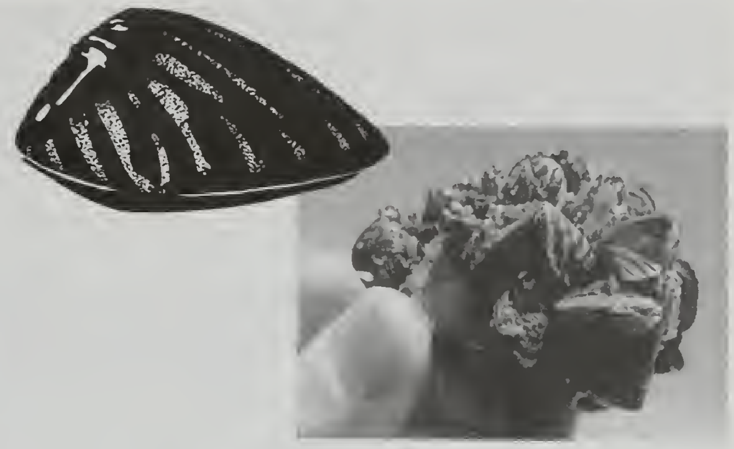


Fig. 3-19. Zebra Mussell (top, *about 1"with dark and light stripes*) and Zebra Mussel Cluster (bottom)

FLOAT PLAN

Before setting out, file a **FLOAT PLAN**. You will find a copy of a suggested float plan in Appendix A in the back of this book. You can cut it out and fill in the descriptive facts about you and your boat. Make photocopies of it and then all you have to do is fill out the rest of the information each time you take a trip.

File your float plan with a friend, relative, or neighbor. The plan tells them where you are going and the route you will take. It also tells them when you will be back and whom to call if you don't return on time. Most often you will ask that the Coast Guard be notified if you are overdue. The Coast Guard does not accept float plans but will mount a search as soon as you are reported overdue.

When you are trailering and you can't find someone to accept your float plan, leave a copy under your windshield wiper. Some police authority will find it, probably soon after dark.

Cancel your float plan when you return! The person with whom you left it may not know you have returned and a needless search may be started.

As a Member of the Auxiliary...

you can participate in many of the Coast Guard's missions such as commercial fishing boat examinations, pollution patrols, radio watchstanding at Coast Guard stations, regatta and safety patrols, search and rescue missions on the water and in the air, plus many more opportunities. You can also participate in Auxiliary programs such as Public Education and Courtesy Marine Examinations.

You will receive valuable training, enjoy the friendship of people with similar interests, and the fellowship of the organization. You will wear the Auxiliary uniform, and assist the Coast Guard in its boating safely activities. There are over 35,000 Auxiliarists involved in one or more of these cornerstone programs.

Contact your instructor for information on how to join the

U.S. Coast Guard Auxiliary.

4

Handling Your Boat

Handling a power boat is a skill that comes through practice and experience. In some respects, it is like handling an automobile. In others, it is quite different.

After you learn the principles, you must practice the skills that grow from them. And you must relearn the skills with each new boat. Each has its own characteristics. These vary with weight, hull shape, type of power, and load. Two boats that appear the same may handle differently. It's up to you to learn the characteristics of your boat.

LEAVE WITH A FULL FUEL TANK

Always keep your fuel tank full. It will help guard against running out of fuel. It also will help reduce condensation in your fuel tank. A partially empty tank has air in it. When the tank cools, some of the water vapor in the air condenses. Thus, when you leave your tank partially empty, you may get water in it.

It's a horrible feeling to look at an empty fuel gauge after your motor sputters and quits. Keeping a full tank is one way to safeguard against this. Another is to follow the "one-third rule." This rule says don't use more than one-third of your fuel on your trip out. Save one-third for the trip back and keep the rest in reserve.

The return trip may take more fuel than you expect. When you go out, the wind and the waves may be calm or they may be from astern. The going is easy. But when you turn around, you may find yourself going into them. Progress may be slow and fuel consumption high. Go out with a full tank and use no more than one-third of it on the trip out. Use one-third on the trip back, and reserve the last one-third for emergencies such as heavy weather.

FUELING YOUR BOAT

With a few simple precautions, fueling a boat's gas tank can be a safe task.

Know What You Are Doing!

When fueling, it pays to know what you are doing. For example, people have pumped gasoline into water tanks. Gasoline has even been pumped into fish rod holders. Both of these errors, on occasion, have resulted in explosions and serious injuries. Be certain that you are pumping the gas into your gas tank and not into your bilge.

Other Precautions

As mentioned in chapter 2, the law requires electrical parts in an enclosed engine space to be ignition-protected. This means that the parts will not produce sparks that can ignite gas fumes. Unfortunately, rebuilt or replaced parts may not be ignition-protected. This could happen, for example, were you to replace a marine alternator with one built for an automobile or when the ground wire on your starter motor might loosen. Should this happen, it will heat and may even glow when you start the engine. An explosion can result.

Keep Fumes Out!

Gasoline vapors are *much* heavier than air. They flow to the lowest spot on your boat. Avoid trapping them. There are many sources of sparks and flames aboard a boat that can ignite them.

Close all cabin doors, hatches, and ports before fueling. This will help keep gasoline vapors from entering your boat. Also, turn off all electrical devices before fueling. These include ventilating fans, radios, bilge pumps, navigational devices, generators, lights, etc. Extinguish all open flames. Turn off the galley stove and don't smoke.

To be on the safe side, operate your blower for at least four or five minutes after fueling. Then, before starting your engine, check all compartments and engine spaces for gas fumes by sniffing. If you have a problem smelling odors, get an electronic fume detector. Remember, though, an electronic device is not always as sensitive as your nose.

The need to thoroughly air out your bilge and other compartments after fueling cannot be overemphasized. It is possible for trapped gasoline vapors to be so rich that a spark will not cause an explosion. When you open a hatch, port, or door, or when your vessel begins to move, you may introduce enough air to make the vapors explosive. Many vessels have exploded and caught fire after leaving the fueling dock.

Built-In Tanks

The filler pipe for your gasoline tank should be located so spills do not enter your boat. A spill inside your boat is dangerous. Clean it up immediately! Leave rags used to clean up a spill safely on shore. Do *not* keep them on your boat. Avoid spills both for the dangers they pose and for environmental protection. A spill that makes a sheen on the water is a violation of the pollution laws. When you see a spill, report it immediately to the nearest Coast Guard Station or facility. You can also report a spill to the National Response Center in Washington, D.C. by dialing 1-800-424-8802.

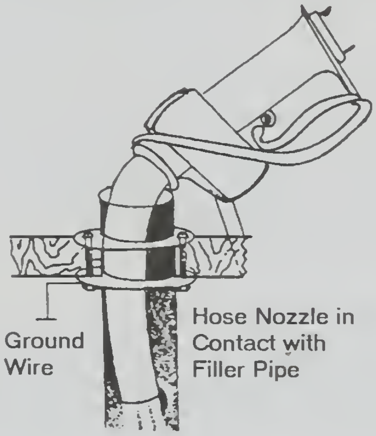


Fig. 4-1. Filler Pipe Deck Flange with Hose Nozzle

Your boat's fuel filler pipe should be connected (grounded) to your boat's electrical grounding system. When filling your tank, keep the hose nozzle in contact with the metal of the fuel filler pipe. Gasoline passing through the hose line from a pump can generate static electricity. A spark between the hose nozzle and the filler pipe can cause an explosion.

Fuel Tank Vents

A built-in fuel tank must be vented outside your boat's hull (see fig. 4-2). This provides an outlet for gasoline vapors and air so you can fill your tank. It also allows air to enter your tank as you use the gasoline. Without a vent, you could not draw gas from your tank without collapsing it.

Vents are covered with a wire mesh that may become clogged from corrosion, insect nests, etc. When this happens, poor engine performance results. The mesh serves the same purpose as a backfire flame arrester.

Unfortunately, both the filler pipe and the vent can cause environmental problems. If you overfill your tank, some of the fuel may spurt out of the filler pipe and into the water. Overfilling a tank usually causes some of the excess to leak out of the vent. You can avoid either of these sources of environmental pollution by knowing the capacity of your fuel tank and never filling it to more than 95% of its capacity.

You can avoid overfilling if you install a fuel fill signalling device in your vent line. This device whistles during fill-up and stops when the tank is full. If you completely fill your tank and then leave your boat in the sun, the fuel will expand and some will leak out of the vent. If a spill occurs and you are in federal waters, it is your responsibility to report it immediately to the Coast Guard.

Portable Tanks

Remove portable tanks from your boat before filling them. Always stay in your boat to put the tank on the fueling dock or to return it to the boat.

When filling a portable tank, keep the hose nozzle in contact with the tank. This reduces the chance of sparking from static electricity.

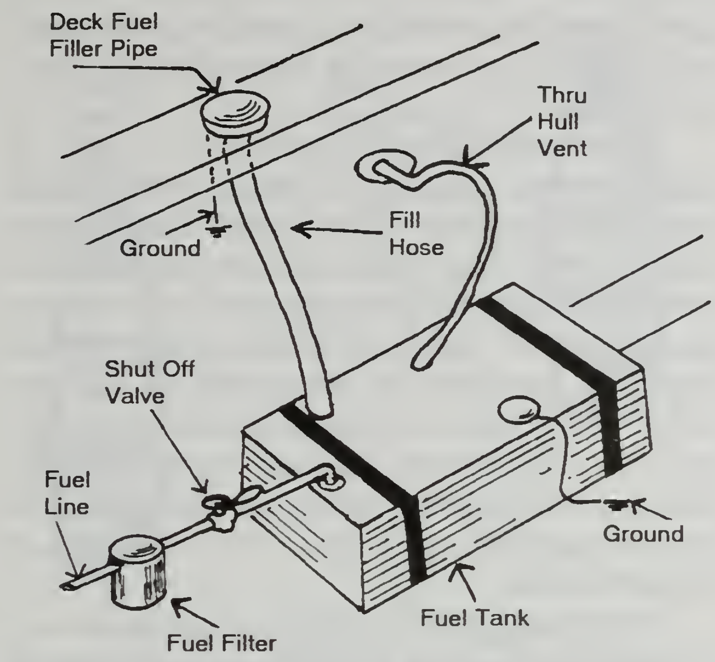


Fig. 4-2. Fuel Filler Deck Plates and Air Vents Must Be Located Outside the Hull.

Gasoline in Your Bilge

If you should find raw gasoline in your bilge, don't operate anything electrical and don't disconnect your battery. Turn off all power by using your enclosed, marine-type battery switch. (If you have an open, "knife" switch, do *not* use it!) A marine-type battery switch is ignition protected and should not produce a spark.

If a spill should occur at a gas dock and it is sizeable, call a fire department. You can clean up small amounts of spilled gasoline with a sponge and a *plastic* bucket. Send the bucket and the sponge ashore. After that, leave the boat open until you can no longer smell fumes. Then use your blower for at least four minutes.

When you don't know where raw gasoline in your bilge came from, look for its source. But do it after you have cleaned up the mess and before you try to start your engine. A leaking fuel line, for example, could be an invitation to disaster.

YOUR BOAT'S PROPELLER

Most recreational power boats use propellers. When viewed from aft, most props turn in a clockwise direction when the boat is moving forward. Thus, they are right-handed. Left-handed propellers also exist. In use, a left-handed prop is paired with a right-handed one on a "twin-screw" boat. A twin-screw boat is one with two engines.

Propeller Characteristics

You describe a propeller by the number of its blades, the direction it turns, its diameter and pitch, and the material used to make it.

Propeller Diameter. The outer edges of a propeller make a circle when it spins. The diameter of this circle is the propeller's diameter.

Propeller Pitch. Propeller blades fasten to their hubs at angles. Thus, the leading edges of the blades tip forward. The degree of tipping determines the pitch of the propeller. The pitch is the distance the propeller would screw itself forward into the water in one rotation if there were no slippage. Although a propeller does not work like a wood screw, you can think of it as if it were a wood screw to understand what is meant by "pitch." The pitch of the screw is the distance it goes into the wood with each complete turn.

Unlike a wood screw, a propeller slips when turning in water. Slip is the difference in how far forward it moves in one turn and the distance it should have moved.

Propeller Size. You describe a propeller's size by its diameter and pitch. For example, it might be a 14 X 12. This means it has a diameter of 14 inches and a pitch of 12 inches.

Propeller Safeguards

There is usually some means of protecting

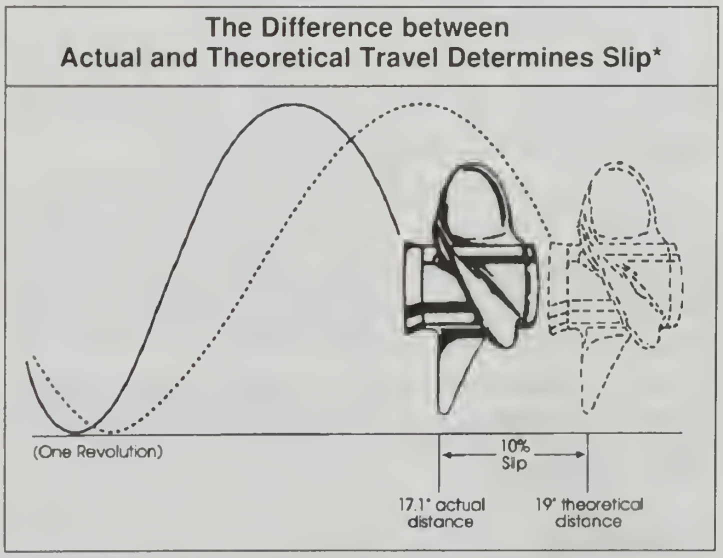


Fig. 4-3. *The theoretical travel distance is determined by the pitch of the propeller which, in this case, is 19".
(Drawing courtesy of Mach Performance Inc.)

propellers, outboard motors, and drive mechanisms. **SHEAR PINS** protect props on small outboard motors. A shear pin is like a soft metal nail without a head. It fits into a hole in the propeller shaft and inside the hub of the propeller. In this way, it keeps the propeller from turning freely on its shaft. When the propeller hits an object that keeps it from turning, the pin shears. This disconnects the propeller from the still-turning drive shaft. It is supposed to happen before you damage either the propeller or its shaft.

Replacing a shear pin is relatively easy unless the boat is in deep water. When your motor is small enough, you can dismount it to change the pin. In shallow water, you can pull the boat ashore or get in the water and replace the pin. Usually, all you have to do is to remove a cotter pin and a nut. The propeller then slides off its shaft. After you replace the pin, put the propeller back on the shaft. Tighten the nut and replace the cotter pin.

A pin can shear even without the propeller hitting anything. Going forward or reversing puts a strain on the metal in the pin. Eventually, through metal fatigue, the pin will shear. *If your propeller uses a shear pin, never leave home without a spare and the tools to install it.*

Larger outboard motors have propellers held in place by the friction of a "slip hub." These propellers slip before the propeller or the shaft is damaged when they hit an object. The hub of a "spun" propeller can be replaced at a propeller repair shop.

You may be able to use a spun prop to return home. Go very slowly. There may be enough friction to turn the propeller.

It's a good idea to take a spare propeller with you. When you spin a hub, you may need to replace the propeller to get home. Also, when you hit a rock or some other hard object, the propeller may be damaged before the hub spins. A badly damaged prop vibrates excessively. Replace it before you damage your motor or its drive shaft.

Cavitation

Propeller blades have sides that curve forward. When a propeller turns, water is forced over its surfaces. Since the water must flow faster over the curved sides than the back sides of the blades, pressure is reduced on the forward sides.

When you reduce the pressure on water, it boils at a lower temperature than normal. When you reduce it enough, it will boil without being heated. When you reduce the pressure on the forward side of a propeller enough, the water in contact with it boils and produces steam bubbles. The hundreds of thousands of bubbles which form release enormous amounts of energy. This causes the propeller to spin wildly without transferring energy to the water. It also damages the propeller. The phenomenon is **CAVITATION**.

Cavitation occurs most frequently when your propeller is too close to the water's surface. It also happens more easily when your propeller is too small for your engine. When it happens, you will hear a peculiar loud whining noise. Reduce the speed of your engine and lower your propeller farther into the water.

Selecting Your Propeller

Your propeller must be the right size for your boat if it is to operate efficiently. Too large a propeller will result in a large amount of slip. When it is too small, you lose energy through cavitation.

Your owner's manual will tell you the full-throttle operating range for your engine in revolutions per minute (RPMs). When your engine turns too fast at top speed, its propeller is too small. Get a larger one. When it turns too slowly, get a smaller one. Remember, size includes both diameter and pitch. A "smaller" propeller can have a smaller diameter, a smaller pitch, or both. Remember, too, that marine growth on your boat's hull will slow down your engine's speed as well as your boat's speed. Before you change propellers, get advice from a reliable dealer.

CARS AND BOATS

The driving force of a boat is at its stern. This is somewhat like the arrangement in a car. In a rear-wheel drive, its rear wheels push it down the road. Other than the effects of wind and water currents, the major differences between boat handling and driving a car are in steering and stopping.

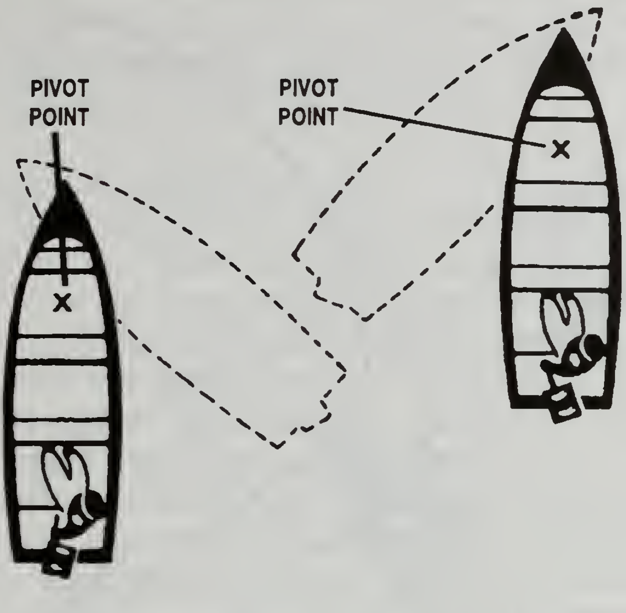


Fig. 4-4. The Directed Thrust of an Outboard or Stern Drive in Forward Gear Moves the Stern of the Boat in a Turn.

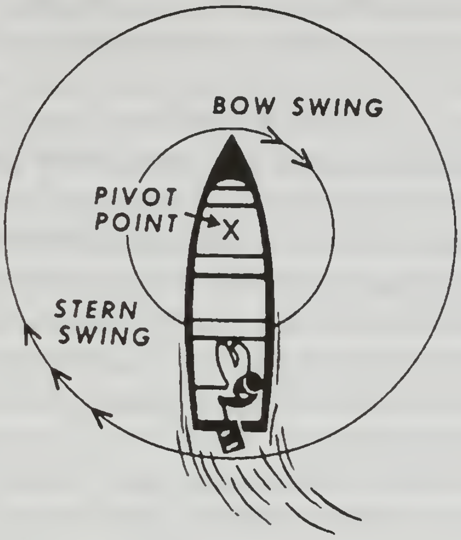


Fig. 4-5. A Turning Boat Pivots About a Point One-third of the Way from the Bow to the Stern.

Steering

Steering is a major difference between a boat and an auto. When you steer a car, the front wheels turn and cause the car to turn. When you turn the wheel of a boat, it is the stern that appears to move first.

When the stern of a boat moves, the entire boat moves. Since the turning force is at the stern, this is the place of greatest movement. All boats have a **PIVOT POINT** somewhere forward of their midpoints. Exactly where it is depends on the underwater shape of the hull, the boat's loading, and other factors. Usually, the pivot point is about one-third of the way back toward the stern from where the boat's **STEM** enters the water.

If your boat has an outboard or a stern drive, steering is done by changing the direction of the propeller's thrust. An outboard motor and its prop, pivot about a vertical axis. With a stern drive, the lower unit and the propeller pivot as a unit.

As long as the outboard or outdrive points directly aft, the thrust is parallel to the boat's keel. Pivoting the prop redirects the driving force. This forces the boat's stern to one side or the other. In forward gear, when the propeller pivots to starboard, the stern moves to port. This forces the boat to turn to starboard. When the propeller pivots to port, the stern moves to starboard. The boat then turns to port.

The way that a boat pivots is not particularly important in open water. Alongside a pier or another boat it becomes critical. Should you operate your boat in "close quarters" like an automobile, you will drive its stern into the pier or the other boat.

The ability to direct the thrust of an outboard or a stern drive gives the boat a lot of maneuverability. It is also possible to turn too sharply causing the boat to turn over or to **CAPSIZE**.

Stopping

Boats also differ from cars in that they have no brakes. Boats slow and stop when you remove power. In an emergency, you can stop your boat's forward motion quickly by applying reverse power. Ordinarily, you would not do this as it stresses the gears and shafts of your motor. Preferably, when going from forward to reverse or *vice versa*, you should first shift to neutral. When the engine has slowed to idle speed, you can again shift gears.

Inboard Engines

A boat with a single inboard engine presents special problems in maneuvering. The engine is forward of the boat's stern and connects to the propeller by a long, rigid shaft. Because of this, you cannot direct the prop's thrust as you can with a stern drive or an outboard. Steering is done by a rudder.

A rudder is a blade that extends down into the water at the boat's stern. In most inboard-powered boats, the rudder is directly behind the propeller's wash. It is turned by a tiller or by a wheel connected to it through a mechanical linkage. Thus, the rudder is directed left or right to deflect the water flow from the propeller and to direct the boat's motion through the water. The stern is pushed in a direction opposite to the deflection. This turns the boat in the desired direction.

Inboard-powered boats have some advantages over outboards and stern drives. In general, they operate more efficiently and more economically. Since their engines are farther forward, they usually ride on a level keel on or off plane. This level attitude plus their larger rudders makes them more acceptable for water skiing. They are less easily pulled one way or the other by the skier.

Larger yachts and commercial craft have inboard engines while few "weekend" boats have them. Because of this and their special maneuvering problems, the interested boater is referred to *Chapman: Piloting, Seamanship, and Small Boat Handling* for further information.[1]

TWIN SCREWS

Boats may have two or more engines although recreational boats usually have no more than two. Some people use two engines because they believe this gives greater reliability. They reason that it is unlikely that both engines will fail at the same time. This is usually true.

The best reason for installing twin engines is improved maneuverability.

Turning with Twin Screws

When you have **TWIN SCREWS**, the starboard propeller is probably a right-handed one. The port prop is left-handed. When you increase the power on your starboard prop while going ahead, your boat will swing to port in a large arc. Conversely, increasing power on the port prop causes the boat to swing to starboard. You can, if need be, steer a twin engine boat by controlling its throttles.

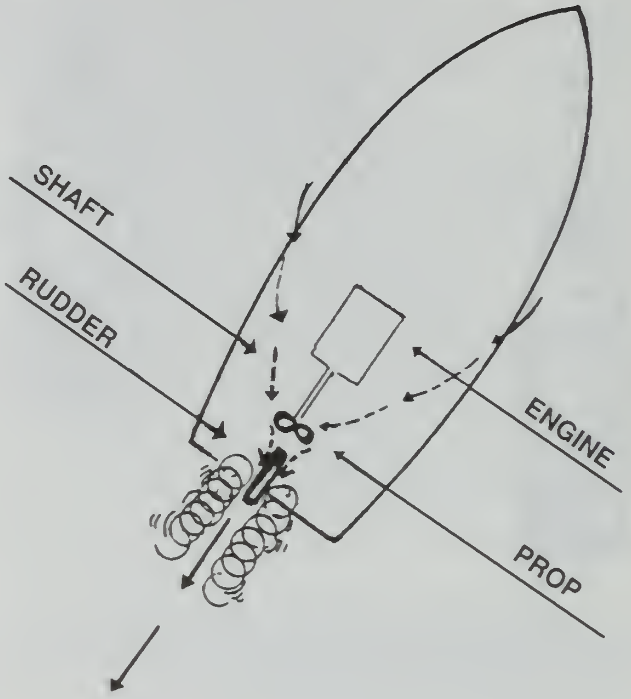


Fig. 4-6. The Discharge Current From the Propeller Flows Over and Acts On the Rudder.

You can make tighter turns by going ahead on one engine and reversing the other (fig. 4-7). Going forward on your starboard engine and reversing your port engine causes your boat to turn sharply to port. Don't do this when you have much **HEADWAY**. You may capsize. With adequate throttle management, your boat can be made to turn without going forward or backward. This can be an advantage in a narrow channel or while docking.

Twin Vs. Single Engines

Although twin engines have their advantages, they also have their disadvantages. The average cost of twin engines is about 1.5 times the cost of a single, large engine. In addition, twin engines require more expensive and complex control systems. Furthermore, they add weight to your boat. Twin engines are about 50 percent heavier than a single large engine of equivalent horsepower.

Twin screws present additional underwater drag and cause greater gas consumption. They use one-third to one-half more fuel than a single large motor. When your twin engines are outboards or stern drives, you have additional weight at the stern of your boat. This affects your boat's attitude in the water.

---

[1] Maloney, E. S. *Chapman: Piloting, Seamanship, and Small Boat Handling*. New York: Hearst Marine Books.

Motor Reliability

The argument in favor of increasing reliability by adding an additional engine loses some of its force in light of the reliability of currently available outboards. Modern outboard motors are highly reliable. Many have dual carburetion, and solid state ignition for each cylinder. Should one carburetor fail, you can usually get home. The same is true when the ignition system on one or more cylinders fails. You can probably still get home. If you should run out of gas, if your "black box" computer module should fail, or if you should "blow" a powerhead, you are out of luck.

Auxiliary Motors

A small auxiliary outboard motor (fig. 3-18) can protect you in case of engine failure. Mount it on a spring loaded board on your boat's transom. When needed, lower it into the water. You must care for your auxiliary motor constantly if you want it to be usable when you need it.

Your auxiliary motor will probably need its own gasoline source. The gasoline in this tank should either be stabilized by using a gasoline additive or changed at least every six months. Old gasoline "gums up" carburetors.

INSTALLATION AND TILT ADJUSTMENT

If your boat has an outboard motor of 25 horsepower or more, it is probably permanently installed on your boat's transom. Of course, all stern drive engines are permanently installed.

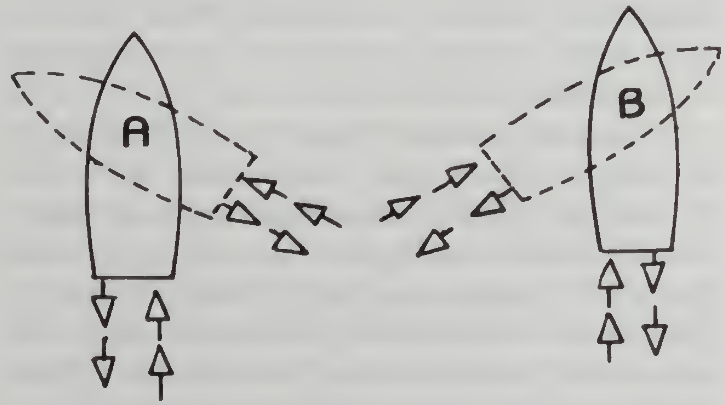


Fig. 4-7. Turning with Twin Screws

Installing a Small Outboard

If you have a portable outboard motor, you will probably take it off at home and store it to prevent theft. Reinstalling it is a simple task. When you mount the motor, be certain that its center is on the boat's centerline. Be certain, also, that you tighten its clamps securely. After you mount the motor, chain it to your boat. It is not unusual for clamps to work loose. When they do, you may lose your motor. Chaining and locking is also a good security move.

The Tilt Adjustment

Outboards and stern drives tilt up or down to adjust the vertical directions of their thrusts and for trailering. Stern drives and larger outboards usually have hydraulic tilting mechanisms. You manually adjust small outboards. For best performance, the thrust of your propeller is parallel to the water's surface when the boat is at its most efficient operating angle. Tilting the motor or outdrive so the propeller is farther forward is called tucking it in or lowering it. Tilting the motor or outdrive farther aft is known as raising it.

When your propeller is too close to the transom, some of its thrust is downward. This lifts your boat's stern and causes it's bow to "plow" into the water. When you tilt it too far back, you force the stern down and the bow is too high. Boats operate inefficiently with improper thrust angles.

You may need to adjust the tilt angle, though, depending on water conditions. In calm, smooth water, raise the prop slightly. It will give you a faster and more fuel efficient ride. In this position, a smaller amount of the boat's undersurface is in contact with the water. In rough water, you may want to lower the prop to bring the bow down and give a smoother ride. When the bow is up in choppy water, you get excessive pounding. But don't tilt it so far forward that the boat plows.

Underway, when your propeller becomes fouled with weeds, it is possible to stop the motor, raise it or the outdrive, and clear it. Should your motor begin to run hot, stop and raise it or your outdrive. Weeds or discarded plastic may have clogged your water intake. Don't forget to lower the motor or outdrive before you again start your motor.

You can also raise your motor or outdrive to clear shoals or to run in shallow water. Be careful, though. Keep the water intake below the surface of the water or engine damage will result. When your propeller cavitates, you must lower it farther into the water.

Some people think the best way to cross shallow water is by raising the outdrive or motor and passing over on plane at high speed. This is not the best procedure, though. In shallow water, a moving boat's stern settles. The settling increases as the boat's speed increases. When you speed up in shallow water, the propeller ejects a large volume of water. As a result, the water beneath the boat moves rapidly to replace the ejected water and it becomes even shallower. It is better to raise your outdrive or motor and to proceed through the shallow water at idle speed.

JET DRIVES

Another form of propulsion is a jet drive. Personal watercraft and some larger boats use jet drives. Such boats have inboard engines but no propellers. Instead, the engine operates a powerful water pump. It pumps water in and ejects it at great speed and volume through a special nozzle. This forceful ejection of water powers the boat. The nozzle turns to one side or the other to steer the boat.

An important jet drive feature is its rapid response to acceleration, stopping, or turning. To stop some jet-driven boats, you lower a barrier, called a "clam shell," into the jet stream. This deflects the stream of water forward. Thus, the vessel stops suddenly—within its own length. All jet-driven vessels have poor maneuverability at low speeds. This is especially important in tight spaces.

Jet drives do not have gear boxes. Furthermore, the pump operates in the same direction when the vessel is going ahead or astern. Thus, you can shift directly from full ahead to full astern without straining the engine. Warn your passengers before this occurs.

Jet drives are popular for sports. Their lack of propellers makes them generally safer for skiing and for operating around swimmers. They can also operate in shallow water without fear of damaging a prop. However, in shallow water they may suck up mud, sand, or debris, and damage their impellers.

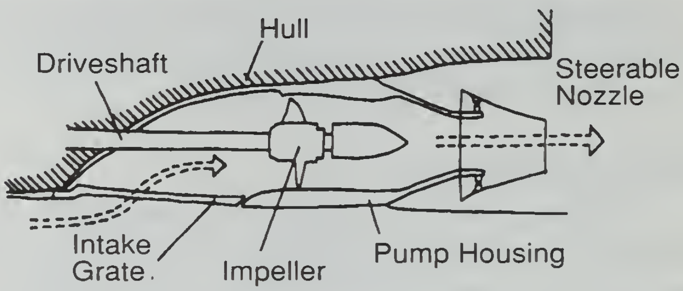


Fig. 4-8. Jet Drive
(Drawing courtesy of Kawasaki Motors Corp.)

The engine of a jet propelled boat is mounted amidships or farther astern with its pivot point about 14 to 20 inches forward of the engine. Thus, sharp turns are possible. These boats can reverse their courses in a little more than their lengths.

LOADING YOUR BOAT

In chapter 2 it was stated that most monohulled power boats less than 20 feet long must have capacity plates. These plates tell you the maximum loads the boats should carry. The plates do not tell you how that weight should be distributed.

When loading your boat, distribute weight evenly fore and aft and **ATHWARTSHIPS** (side to side). The more weight you put into a boat, the deeper it sinks into the water. This reduces its freeboard. The more you reduce the freeboard, the greater the tendency to swamp or capsize. This means that the greater the load, the more likely your boat is to fill with water or turn over. An overloaded or improperly loaded boat is unstable and dangerous.

Passengers often violate the caution about balancing the load fore and aft and athwartships. Too many of them may seat themselves forward causing the boat to plow through the water. Some may seat themselves on a gunwale or the transom. Those on the gunwale may cause the boat to **LIST** to one side. Those on the transom may cause it to be stern heavy. All of these conditions can make the boat difficult to handle. Most of them are also violations of the law. The skipper should move the passengers to "trim" the craft.

Whether you should carry the maximum weight shown on your capacity plate, depends on several factors. First, you must consider the sea state or water conditions. When you expect rough water, carry less weight. A heavily laden boat will **SHIP WATER** easier than one riding higher in the water. When a boat ships water, water comes in over the gunwales or the transom.

Second, consider the activity you expect to engage in underway. When you are fishing, someone will want to stand up. Standing up in some small boats is dangerous. It becomes more dangerous in choppy water or when the boat is heavily laden. When you stand up in a boat, you raise its center of gravity, the point where its mass is centered. Raising the center of gravity increases the chances of capsizing the boat or of your falling overboard. Falling overboard is always dangerous.

The greatest number of fatalities in boating result from boats capsizing and from people falling overboard.

Learn and practice the techniques for reboarding a small boat or for recovering a person overboard. Reenter a small boat by climbing over its bow or its stern. Attempting to reenter a small boat by climbing over its side, may swamp or capsize it. Practice reducing your boat's speed and coming about to recover a person in the water. You never know when you will need to do it.

Falling overboard is even more dangerous in cold water. Immersion in cold water, even for a brief period, carries with it the danger of *hypothermia*. It occurs whenever a person's body loses large amounts of heat and is unable to maintain its temperature. When you are immersed in cold water, your heat loss is large. It is also large when you are exposed to strong, cold winds, especially when you are wet or if you are under the influence of drugs or alcohol.

The best approach to hypothermia is to prevent it. Take steps to see that you do not fall overboard. If you should fall overboard, get back in the boat and out of the wind as soon as possible. Eat a good meal to provide yourself with reserve energy before you enter situations in which you may be exposed to hypothermia. Wear warm clothing and avoid long periods of exposure to cold winds. Hypothermia is discussed in chapter 13.

Other factors to consider in loading your boat are the weight of the equipment, fuel, tools, food, and other gear that you are carrying. The more gear you have aboard, the less capacity you have for passengers.

Even when you have loaded your boat correctly, you may have problems under adverse conditions. Running too fast in choppy water can buffet a boat excessively and damage it. You may also lose control when your boat is buffeted too much. Hitting a wave too fast can cause you to flip. You can capsize should you turn too hard.

GETTING STARTED

Before getting underway, check the weather and your vessel's systems and gear. You will want to make and use a check list. Make sure your boat's registration is aboard.

Before You Start Your Engine

Brief Your Guests. Guests should be familiar with your boat and its safety equipment. Before you start your engine, show them where the life jackets are located, and help fit them to each person. Show them how to start and stop the engine and how to operate the radio. In the event of an injury or the illness of the skipper, someone else should be able to operate the boat and its radio. Also, show them where the fire extinguishers are kept and how to operate them. While you are orientating your guests, let them know that no trash is to be thrown overboard.

Get a Weather Check. Before you cast off, get an up-to-date marine weather forecast and be guided by it. When stormy weather or rough water is predicted, you may want to cancel your trip. If you should go, load your boat according to the weather conditions you expect to meet.

The most readily accessible and accurate forecasts are those given by the National Weather Service (NWS). You can get these on your VHF-FM radio. They are broadcast on a continuous basis and updated as new information is received. Listen to them from time to time as you cruise to see if there have been recent developments.

It is also important that you learn the fundamentals of weather and its prediction. In this way you can be alert to changes in the weather as they occur. You can learn more about weather in chapter 10 of this book.

Emergency Needs. Since water is not a medium in which people can survive, there are a few precautions you should take. Should trouble develop, you will want to be prepared for it.

When you leave, the day may be warm and sunny. You plan to be back well before sundown. Then trouble develops. Be prepared for it. Number one on your list should be a reserve supply of drinking water. Include some warm clothes, too. It can get cold on the water after sundown. It's a good idea to have a warm blanket aboard. It's also a good idea to have some mosquito repellant when mosquitoes are in season.

Sun screen is a requirement, too. On the water, several factors can combine to give you a bad sunburn. The direct sunlight is one factor of course. Almost as bad, though, is the sunlight reflected from the water. And a third factor is the wind. A strong breeze sensitizes your skin and makes it easier to burn.

Life Jackets. Take your life jackets out of the locker and put them where they are immediately accessible. Have each person fit one before leaving the dock. Make sure that guests have life jackets assigned and fitted and they know how to put them on. Better still, have everyone wear life jackets. It is difficult to don a life jacket in the water. In cold water it may be impossible.

Throttle and Steering. Take the time to check your throttle, gear shift lever, and steering mechanisms. This is especially important when you use your boat in salt water. These mechanisms can corrode and "freeze." It is, at the least, embarrassing to find that you can't shift gears or turn your steering wheel after you have pushed off from the pier.

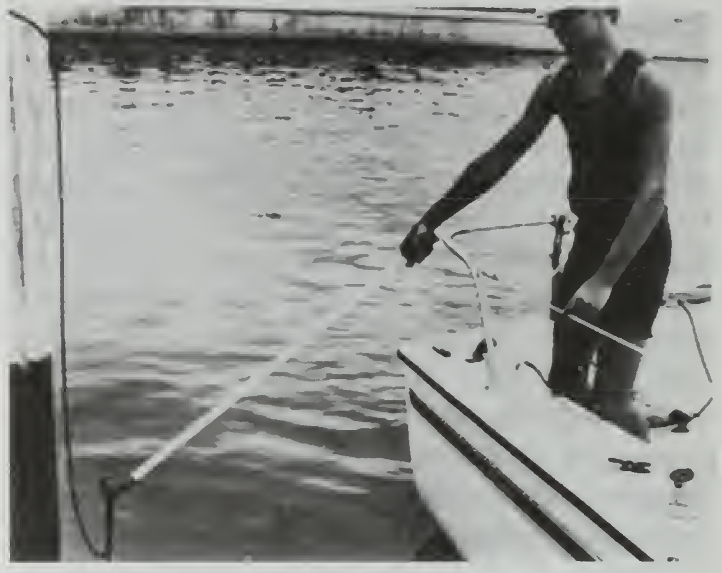


Fig. 4-9. Boathooks Lend a Hand.
(Photo courtesy of Beckson Marine, Inc.)

Other Equipment. Have you brought all the equipment on board you will need? This includes your electronic equipment such as Loran and depth finders, if you have them. If you removed your radio, did you remember to install it again? Do you have your anchor and enough line to anchor in the water along your route or at your destination? In an emergency you may have to anchor in deeper water than you planned.

Do you have your whistle or horn aboard? Is it in working condition? Permanently installed horns rust and corrode. When they do, they no longer work.

You should also have a **HEAVING LINE** and a **BOATHOOK** available. A heaving line is a light line weighted at one end. It is useful when you need to throw a line to another vessel or to a person on the pier should you have trouble docking. The boathook can aid in mooring and docking as well as in retrieving objects dropped in the water.

Check your Gas and Oil. Check to see that you have a full fuel tank. When you have a stern drive or inboard engine, check its oil level. If you have an outboard motor that automatically mixes oil with the gasoline, check to see that this oil tank is full.

Following this, check all of your lights including your running lights. This is necessary even when you don't plan to be out after dark. You never know when you will encounter rain or fog, or an unavoidable situation will keep you out late. Should your lights not be working properly, fix them before you go.

Starting Your Engine

Check enclosed spaces, including the cabin and engine compartment, for gas fumes. Even when you don't smell fumes, run your blower for four or five minutes before starting your engine. You are ready now to start your engine.

After you start your engine, allow time for it to warm up. This will keep you from stalling as you shift into gear to leave the pier. Avoid excessive idling. Your engine's lubrication is usually poorest while idling.

While you are waiting, check the **TELLTALE** of your outboard motor. If the water to cool your motor exits through the exhaust, check to see that it is flowing freely. For any engine, keep an eye on the engine thermometer to see that it is not overheating. When your outboard motor has a warning horn, heed it if it should sound. When it does, shut down your engine. Then check the water intake. Illegal disposal of plastic is a frequent source of intake problems. If you have a stern drive or an outboard, shut the engine off. Then raise the motor or the outdrive to see if anything is clogging its intake ports.

Also while you are waiting for the engine to warm up, check all gauges to see that everything is functioning properly. Is your alternator charging correctly? Does your voltmeter show problems with your battery? If you have a stern drive or inboard engine, do you have enough oil pressure?

Getting Underway

With the engine warm and all gauges operating normally, it is time to get underway. Secure all loose gear about the deck, and after you have cleared the pier, take in all **FENDERS**.

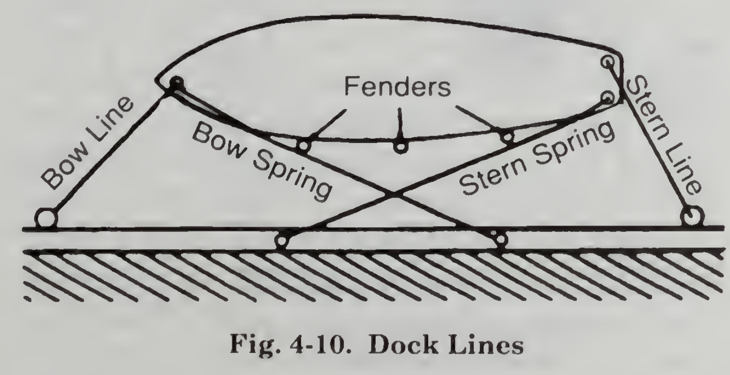


Fig. 4-10. Dock Lines

Before casting off, pay special attention to the direction and strength of the wind and water current. You will need to work with these as you leave and when you return. Also note all hazards and obstructions in the area.

To cast off, untie all lines you will not use in maneuvering away from the pier, and bring aboard those you will take with you. Stow them where they are readily available and where they will not be a hazard. Some skippers leave their lines at the pier so they will be there to tie up with when they return. Take at least a bow and a stern line with you. You may want to stop for fuel or for lunch and you will need them at that time.

Figure 4-10 shows lines that will safely moor your boat to a pier or a seawall. If you have tied these lines with appropriate knots, they will be easy to untie and cast off. The best knots for mooring purposes are clove hitches, half hitches, and belaying to a cleat. See chapter 9 for a discussion of these and other knots.

Remember that as you leave the dock you will be moving at **IDLE SPEED**. Most marinas have a five knot or five mile per hour speed limit. You are liable for and may be cited for negligent operation for any damage caused by your **WAKE** or wash.

LEAVING A PIER

The procedures for leaving a pier are identical for single and twin screw outboards and stern drives.

No Wind/Current

When there is no current and the wind is not strong, the easiest way to leave a pier in a boat less than 30 feet long is to push off from it. Once your boat is far enough away from the pier, you can go into forward gear.

If you try to leave the pier by going forward, you may find yourself bumping along its entire length. When you turn your boat, your stern moves sideways. It moves farther and faster than the bow. When you try to go forward and turn out, you will not turn your bow out. Instead, you will turn your stern into the pier.

A simple way to leave a dock is by backing out. Turn your motor or lower unit in the direction you want the stern to move then back out slowly. Once you are clear, go forward. (Please remember, we are not discussing inboard boats.)

Wind and Current

Wind and current have different effects on different boats. You will need to experiment to see their effects on your boat. However, some generalizations are possible.

Deep draft boats, with comparatively low profiles are less affected by wind than by current. There is less boat above the water upon which the wind can act. There is also more boat in the water on which the current can act.

Generally, the bow of a powerboat is higher than its stern and is considerably lighter. Thus, the bow almost always turns away from the wind. This leaves the stern, with its lower freeboard, pointed toward the wind and waves when the boat is not anchored.

Wind/Current off the Pier

When the wind and current are coming from the direction of the pier (fig. 4-11), getting underway is simple. Cast off all lines. Then let the current and wind carry you far enough away from the pier to allow safe maneuvering.

Wind/Current on the Pier

The wind and current may be moving toward the pier. If so, this presents a more difficult problem. With an outboard or a stern drive, it is easiest to back away. With all lines cast off, turn your helm away from the pier and back out slowly. When you are far enough away from the pier, you can turn and go forward.

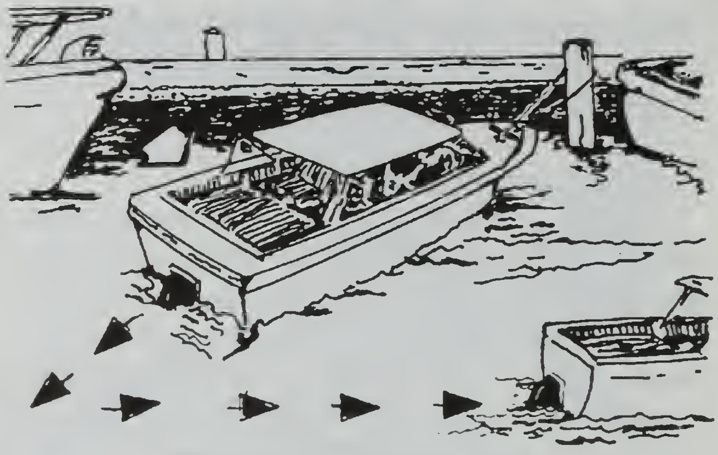


Fig. 4-12. Using a Bow Line

Should you find yourself in close quarters with the wind or current moving onto the pier, you may need to do something additional. In this case, use your bow line to help you. Fasten one end to your bow and run the line around a **BOLLARD** (post) or a **CLEAT** on the pier. Hold the other end of the line on the boat around a cleat. Now turn your helm away from the pier and back out slowly. The stern will swing out. You can then straighten your helm, retrieve your line and back out.

Wind/Current on the Bow

The wind/current on the bow presents a simple situation for an outboard or a stern

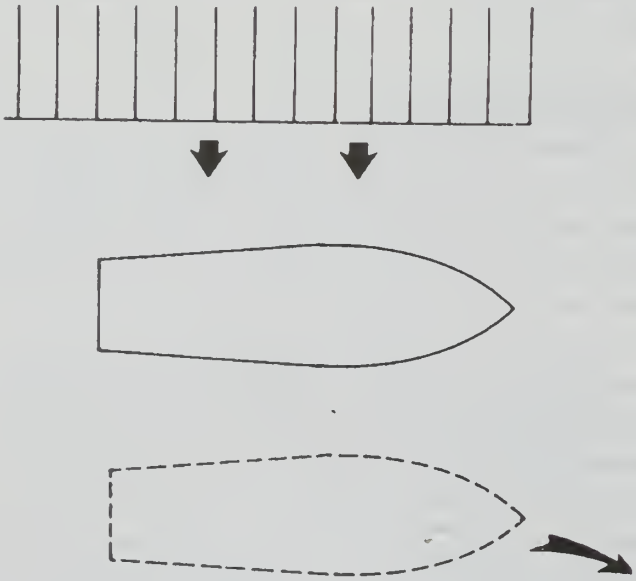


Fig. 4-11. Leaving a Dock, Wind Blowing Off the Pier

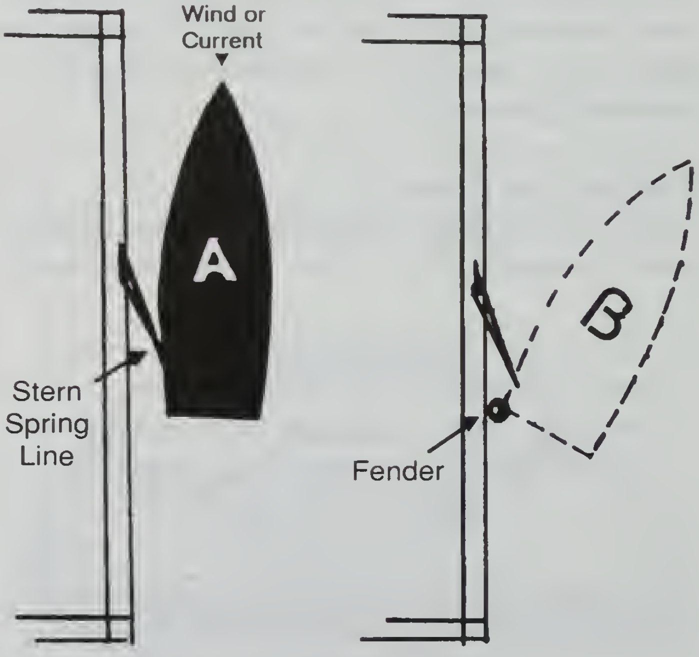


Fig. 4-13. Leaving a Dock, Wind on the Bow

drive powered boat. Push the bow away from the pier and go forward at idle speed. The wind or current will turn your bow out and you can go straight forward. This works even in close quarters.

If necessary, you can use a stern spring line to hold your boat in place as the bow swings out. Run the line from a stern cleat around a cleat or a bollard on the pier and back to your boat. You will want to run the free end around the stern cleat, not tie to it, so it can be released and retrieved. In this way, you can retrieve your line when you are free of the pier.

Wind/Current on the Stern

Having the wind/current on the stern usually does not present a problem for either an outboard or a stern drive engine. Unless you are in close quarters, push away from the pier and go slowly forward until you clear it. In close quarters, you can use a bow spring line. Run it from a bow cleat, back around a bollard, and back to your boat. Hold the line by means of the bow cleat but do not tie the free end to the cleat. Turn your propeller away from the pier and back out. When you are clear, retrieve your line.

Turning in a Narrow Channel

You may find it necessary to turn 180° in a channel that is too narrow for your boat's turning circle. A twin-screw boat will have no problem. Neither is there much of a problem for an outboard or stern drive when the wind is on the bow. In this case, hug one side of the channel and make a sharp turn toward the other side of the channel. At the same time, reduce your engine speed and shift to neutral. The wind will bring the bow around and you are on your way.

When the channel is too narrow for a complete turn and the wind is not a factor, hug one side and begin a sharp turn toward the other side of the channel (fig. 4-14). Again, shift into neutral. As the boat swings around, turn your helm all the way opposite to the turn you are making. Then shift into reverse and back away. Now, shift into neutral and turn your helm all the way in the direction of your turn. If you now go forward, you will probably complete your turn. If not, continue with the procedure until you do.

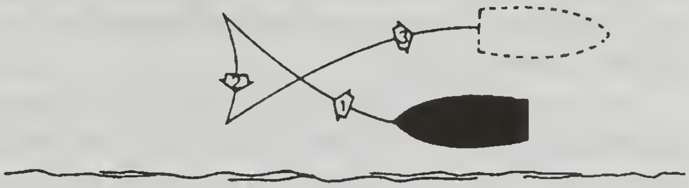


Fig. 4-14. Turning a Boat in a Narrow Channel

When the wind is from your stern, you will have a different problem in a narrow channel. As you turn your bow, the wind blows across it. Thus, your bow may stop turning and you will go sideways up the channel. In this case, you will probably find it easier to turn if you hug one side of the channel and stop. Now, turn your helm all the way to the opposite side of the channel and shift into reverse. Your engine will pull your bow around into the wind. Often it is easier to turn in a narrow channel by reversing instead of going ahead. In part, it depends on the characteristics of your boat.

When the wind is strong and from your stern you may not be able to turn even by backing. In this case, lower your anchor. The wind will cause you to fall back on the anchor bringing your bow into it. Now as you head into the wind, retrieve your anchor line and anchor. This maneuver requires quick action by the person tending the anchor. Use it only in extreme cases.

Watch Your Wake!

There are a variety of speed signs you will meet. An **IDLE SPEED ZONE** is a zone in which your boat must go no faster than necessary to steer it. A **SLOW SPEED** zone is one in which your boat must not be on a plane and must be level in the water.

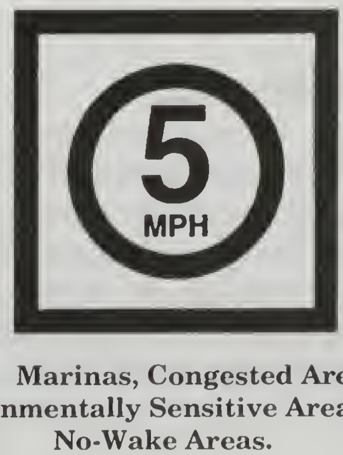


Fig. 4-15. Marinas, Congested Areas, and Environmentally Sensitive Areas Are No-Wake Areas.

A planing vessel goes through three stages as it increases its speed. At slow speeds, it is a displacement boat.

As a planing vessel accelerates, its stern sinks and its bow rises. When this happens, you cannot see the water immediately in front of you. A large wake follows your boat as water rushes in to fill the "hole" made by its passage through it.

In this stage, your boat is dangerous to other boats and to property and is most costly to operate. Its wake can rock other boats and swamp smaller ones. People in other boats may fall and injure themselves or fall overboard and drown.

Your wake can damage seawalls by undercutting them. Immature sea life in nearby wetlands can be harmed. Run your boat slower or faster than this intermediate speed! This assumes that there are no speed restrictions. When there are, slow down so you leave this second stage.

When you increase your power, your vessel enters the third stage and rides up over its bow wave and "gets on plane." When this happens, both its bow and fuel consumption drop. It still makes a wake but not as much as in the second stage. The boat again feels comfortable. When you pass other people, stay far enough away that your wake does not disturb them. Should you not be able to stay away from them, slow down until you are off the plane and on a level keel, that is, the first stage.

As a planing vessel slows down, it passes through the above stages in reverse order. A planing hull usually settles quickly once you reduce power, and it stops in a relatively short distance. In fact, you must avoid slowing down too quickly. Your wake will overtake your boat and may swamp it as it comes in over your transom.

"MAN" OVERBOARD

Underway, there is always a risk that someone will fall overboard. (That's one of the reasons you wear life jackets.) When this happens, every moment is important. Rehearse how you and your crew should react. If you have guests aboard, explain your procedures to them before you go.

Sound the Alarm

What is done in the first moments after someone falls overboard will determine the success or failure of the recovery. The first person to realize that someone has fallen overboard should immediately shout an alarm. At the same time this person should throw anything that floats, such as a life ring, a seat cushion, or a life jacket toward the person in the water, and indicate where the person is by pointing. Above all, do not lose sight of the person in the water.

Each object you throw should have a **POLYPROPYLENE** line attached to it (polypropylene line floats). If the person in the water is conscious, the line may be of aid in retrieving the object. It may also aid you in pulling the person in toward the boat.

If you give the alarm, do it in a loud voice and indicate from which side of the boat the person fell. For example, shout, "Man overboard, port side!" Keep shouting until the skipper hears and understands.

Returning to the Victim

The skipper must take action as soon as the alarm is sounded. Turn the boat in the direction the person fell. For example, if the person fell from the starboard side, turn to starboard. This turns the stern of the boat and its propeller away from the person in the water. At the same time, the skipper attempts to mark the spot where the accident occurred. This can be done by punching a way-point into the Loran-C, by visually noting the location, or by any other means available.

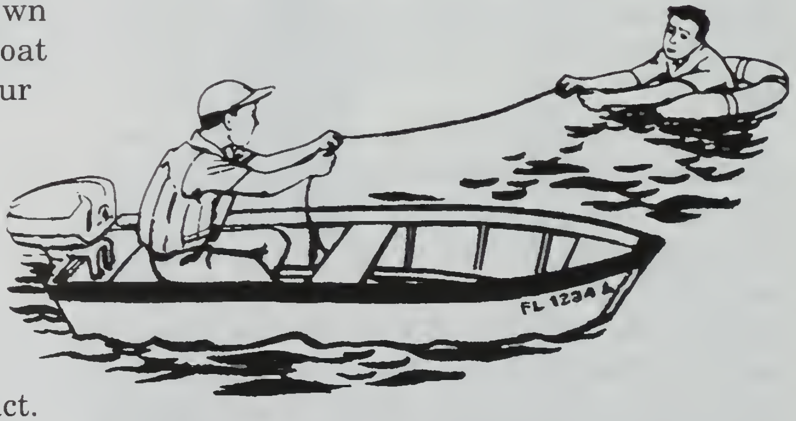


Fig. 4-16. A polypropylene line is attached to the object thrown to the person in the water.

The skipper turns the boat and proceeds rapidly until close to the person in the water. The approach is then slowed and becomes deliberate. The engine is stopped and the boat coasts in. The best approach is from **LEEWARD**. If the seas are rough, however, this may not be possible. An approach from upwind in rough seas carries with it the danger of overrunning the person in the water. If you "overshoot," do not try to back down to the victim.

Retrieving the Victim

If your boat is very small, it may be necessary to bring the person in over the bow to keep from capsizing it. Otherwise, bring the person in over a gunwale, if a boarding ladder is not available. If a ladder is not available and there is considerable freeboard, make a "step" by tying a loop in a line using a **BOWLINE KNOT** (see chapter 9). Tie the other end of the line to a cleat on the opposite side of the vessel.

If the person in the water is unconscious, it may be necessary for someone to go into the water to give assistance. Avoid this if at all possible. It means an additional person in jeopardy and to be retrieved. If someone does go into the water to give assistance, have that person put on a life jacket and tie a line to it. Have someone aboard tend the line. When the rescuer reaches the victim, use the line to bring both of them back to the boat.

If two people are available to assist the injured person, turn the victim's back to the boat, reach under the armpits, and lift straight up to a sitting position on the gunwale. If only one person is available to aid the stricken person, turn the victim's face toward the boat, cross the victim's and your hands, grab both hands with yours, and lift. As you lift, uncross both sets of hands, thus, turning the victim like a corkscrew. Again, pull the victim to a sitting position on the gunwale.

As an alternative method, run a line under one armpit of the victim, across the chest, and back under the other armpit. Use the line to lift the victim out of the water. In any case, use the natural roll of your boat to assist you.

DOCKING

Docking a boat can be a source of pride or embarrassment. Some skippers approach a pier at breakneck speed and throw their engines into reverse. If they don't go through the pier, they get alongside just in time to be pounded against the pilings by their own wakes.

Don't be a "hot rodder." Make your approach cautiously and slowly. All you need is enough speed to steer your boat. This approach doesn't look as spectacular, but it is better seamanship. It is also good seamanship to have fenders, mooring lines, a heaving line, and at least one long line ready in advance of docking.

If you have a choice, approach the pier or mooring with your bow headed into the wind or the current. Downwind docking is difficult and requires more skill than docking into the wind. There are times, however, when you cannot avoid such an approach.

Plan your approaches carefully. Downwind approaches require extra care and planning. A bad approach can cause your boat to slam into the wharf or another boat with costly results. In any case, it is hard to make your boat stop when you want it to when you are going downwind or downstream.

If you see that you are going to have a problem with your approach, start over. It is much better seamanship to try again than to have a bad, and perhaps, dangerous approach. Prudent skippers try to foresee and prevent problems before they happen.

Docking with No Wind or Current

Make an approach where there is no wind or current by bringing your bow slowly alongside the wharf, pier, or float. Approach slowly and, when necessary, reverse your engine to stop the boat.

Wind Blowing off the Pier

When the wind is blowing across the pier toward you, as in figure 4-17, head into it at a relative large angle. The stronger the wind, the larger will be the angle of your approach. In a very strong wind, your approach will be straight in or perpendicular to the pier.

When close to the pier, send the bow line ashore and tie it off. Then put your helm hard over toward the pier and reverse your engine slowly. This will bring your stern around to the pier. Place a fender between the pier and your boat as you reverse.

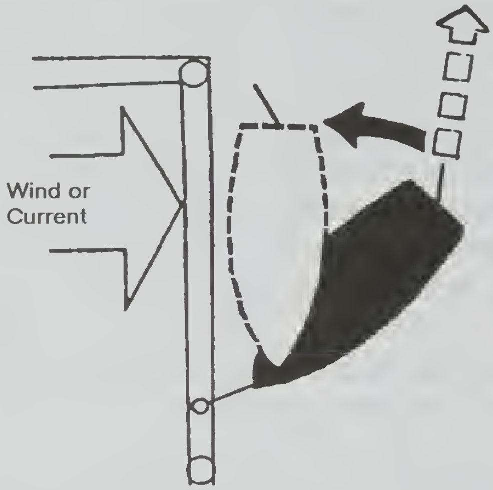


Fig. 4-17. Docking From Leeward

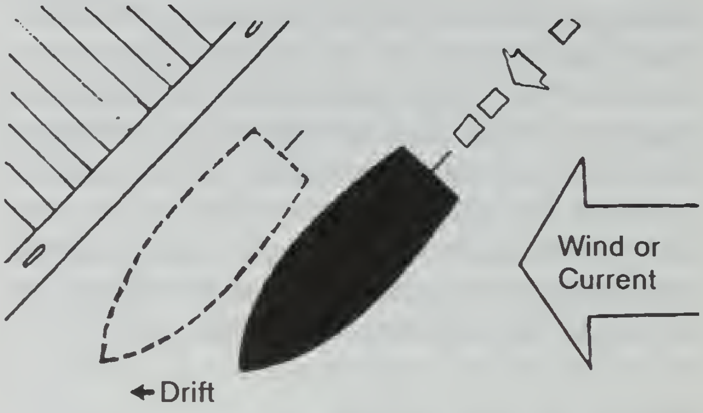


Fig. 4-18. Docking From Windward

As an alternative, after you have a bow line secured, send a stern line ashore. Someone can then pull your stern into the pier.

Wind Blowing Onto the Pier

When the wind is blowing toward the pier, you have an easy approach (fig. 4-18). Ease your boat up to the pier and let the wind blow you to it. Since your bow will fall off quicker than your stern, turn your helm away from the pier. Then, should it be necessary, ease your boat forward. This will bring the stern in to the pier.

Always have fenders ready to cushion the impact of your boat and the pier. When the wind is strong, the impact may be considerable. *Never* use arms or legs to fend off as your boat approaches the pier. Arms and legs have been broken or seriously crushed in this manner. Your boat is heavy and its momentum is great. A heavy boat even though moving slowly has a lot of momentum.

MOORING TO A PERMANENT ANCHOR

Mooring buoys fasten to permanent anchors sunk deeply into the bottom (fig. 4-19). You will find them near yacht clubs and in some harbors. They are there for the convenience of yachters. In the Florida Keys, you will find them in favorite diving spots. They are there so boaters will tie up to them instead of anchoring in the coral reef and damaging it.

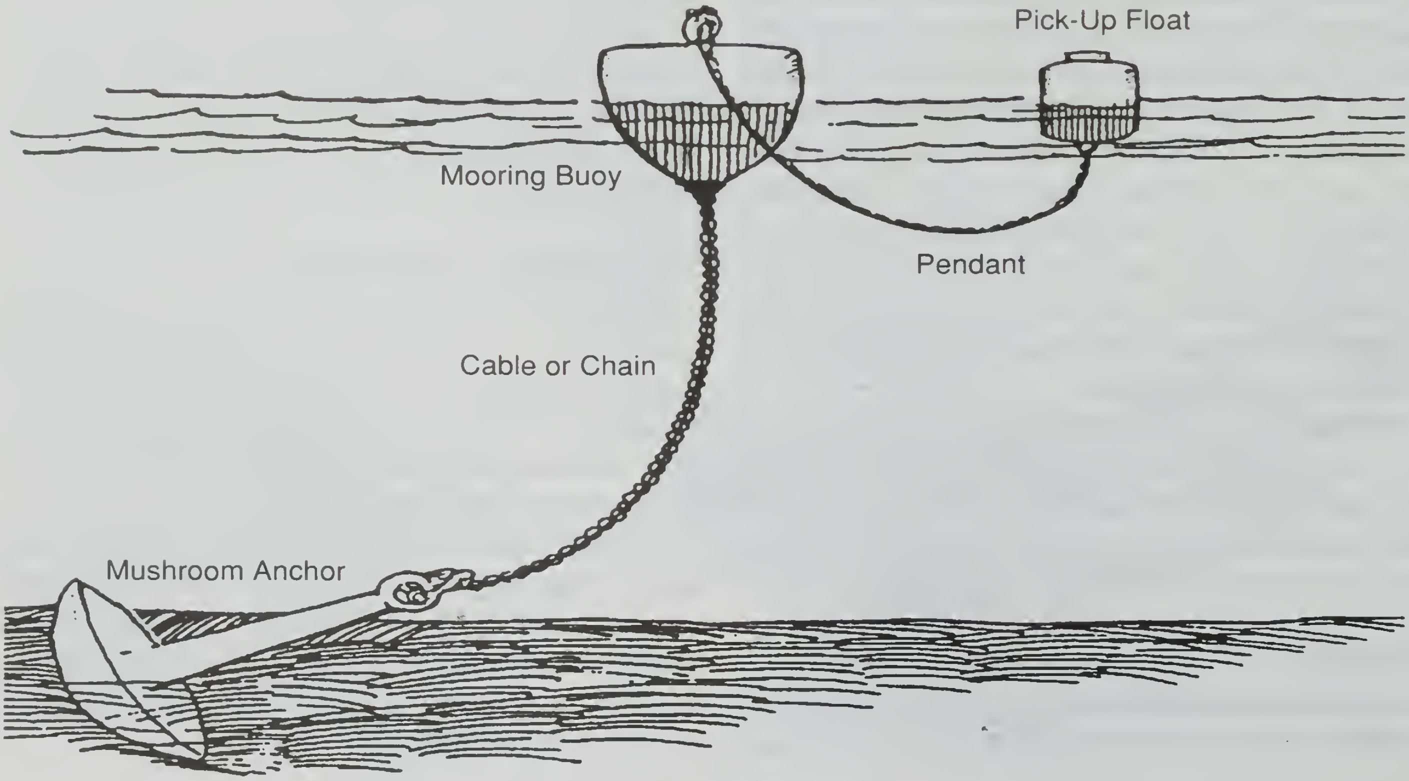


Fig. 4-19. Typical Mooring Rig

Mooring buoys are the only ones boaters may tie up to legally. Mooring to any aid to navigation, including buoys, is illegal. Many mooring buoys are privately owned. You should have permission before you use them.

As you approach a buoy, remember that some boats are more sensitive to wind while others are more sensitive to current. Approach the buoy against the force of the wind or current, whichever is stronger. When other boats are moored in the vicinity, see how they are heading. You can adjust your approach to parallel them. Shift into neutral when you see that you have enough forward motion to reach the buoy.

There is a float attached to the buoy by a **PENDANT**. Have someone pick it up and bring it aboard. Secure the pendant to your **BITT** or a bow cleat. After you have tied to the pendant, stop your engine and let your boat drift back.

If you misjudge your approach, continue around and try again. This is better seamanship than trying to back down to the buoy.

Some boaters moor both fore and aft or moor forward and anchor aft. Either of these practices is discouraged. Tide and wind changes can swamp or capsize your boat.

Leaving a mooring is a simple operation. About the only problem is keeping the pendant out of your prop. You can do this by going astern slowly and dropping the pendant when there is no longer a danger that it will foul the prop.

ANCHORING

Every skipper should master the art of anchoring. You need it for protection and for the enjoyment of boating.

Equipment

Anchoring equipment is called **GROUND TACKLE**. The type of ground tackle you will have depends on several factors. These include the type, weight, and length of your vessel. Also of importance are the characteristics of the bottom and the depth of the water in which you will anchor. You must also consider the strengths of the wind and current. To be adequate, your ground tackle must hold your boat securely under the most adverse conditions.

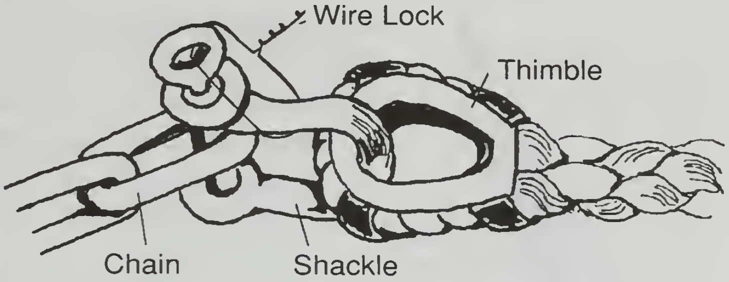


Fig. 4-20. Shackle and Thimble

Anchor Rode

The **RODE** of an anchor is its line and chain. An effective combination consists of four to six feet of heavy chain, a shackle, a **THIMBLE**, and a nylon line. The chain helps the rode lie flat on the bottom thus enabling the anchor to dig in. It also protects the rode against chafing in rocky bottoms.

The shackle is a "U" shaped metal device with a pin or bolt across its open end. It connects the chain to the line. Secure the pin or bolt by a piece of stainless steel wire. It can work loose causing you to lose your anchor.

The thimble is a horsecollar shaped metal or plastic device that is inserted in the eye at the end of the anchor line. Its recesses accommodate the anchor line. The thimble keeps the anchor line from chafing on the shackle.

Nylon makes an excellent anchor line. Its elasticity eases the shock of the boat's movements on the anchor. The anchor chain also serves the same purpose. As your boat surges, the chain rises and falls easing the strain on the anchor.

Types of Anchors

There are several types of anchors. The choice of one over another depends mainly on the type of bottom in which you will anchor. Some have greater holding power than others.

Danforth. The most popular anchor for small recreational craft is the Danforth (fig. 4-21). It is a lightweight anchor with long, narrow, twin flukes that are the anchor parts that dig into the bottom. A **DANFORTH ANCHOR** is of little use on a grassy bottom. It slides across the grass rather than digging in. It works well in mud and sand but may hang up in a rocky bottom.

You can attach a trip line to a Danforth

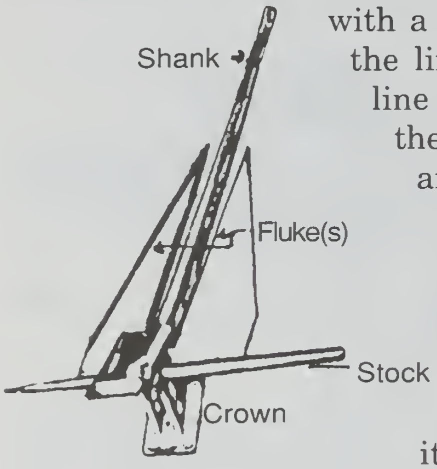


Fig. 4-21. Danforth Anchor

with a buoy on the end of the line. Attach the trip line to a hole drilled in the crown. When the anchor hangs up, you can retrieve it by this line.

There is another means of recovering a Danforth when it hangs up. Attach your anchor line to a hole in the crown. Also fasten your anchor line to the anchor ring by a relatively weak line. When the anchor hangs up, tie off the anchor line to a cleat or bitt and go forward slowly. Be careful not to foul the line in your prop. When you have gone far enough, the line fastening the anchor line to the ring will break. Going farther forward will usually pull the anchor loose.

A modified Danforth anchor exists that is reasonably easy to free when it hangs up in rock. This anchor has a slotted shank containing a movable ring to which the anchor rode is attached. When the anchor hangs up, run back across it with a slack line. Then pull the line tight and tie it off on a cleat. This usually brings the ring down to the crown and a slight pull will free it.

Anchoring with this modified Danforth requires some skill. As you lower it, keep a taut line. When the anchor hits bottom, back your boat down while keeping slight pressure on the anchor line until the anchor digs in. Should you not follow such a procedure, the ring may slide to the crown. This will cause the anchor to slide across the bottom instead of digging in.

Yachtsman's Anchor. The **YACHTSMAN'S ANCHOR** is an adaptation of the ancient kedge. Its **FLUKES** have sharp **BILLS** for good penetration of the bottom. The flukes' diamond shapes permit the anchor line to slip past them without fouling. This is important when your boat swings with a changing current or wind.

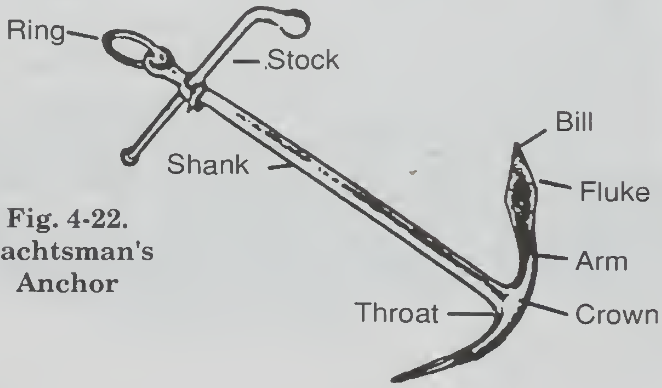


Fig. 4-22. Yachtsman's Anchor

The yachtsman's anchor has a shape that makes it awkward to stow. Some models can be partially disassembled for stowing. Long-range cruisers often carry these anchors for storm anchors.

Mushroom Anchor. A **MUSHROOM ANCHOR** is **STOCKLESS**. It has a cast iron bowl at the end of its **SHANK**. In large sizes, it is used for permanent moorings. Mushroom anchors gradually dig deeply into the bottom. When embedded, they have tremendous holding power. Small mushroom anchors are used by fishermen. They can hold a boat well in mud or sand in calm, protected waters. They do not work well in grassy and rocky bottoms.

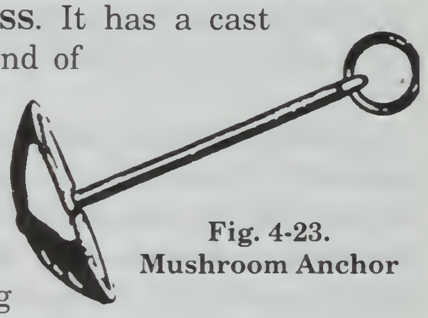


Fig. 4-23. Mushroom Anchor

Grapnel. A **GRAPNEL ANCHOR** has a straight shank with four or five curved claw-like arms and no stock. You can use it in rock with the deliberate intention of hooking under one. It's a good idea to tie a line, with a buoy on it, to one of the arms. This trip line will help you retrieve the anchor. If your grapnel does not have a **TRIP LINE** attached to its **CROWN**, you won't have it long. It will hang up under a rock.

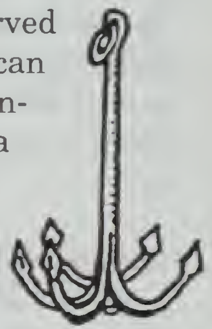


Fig. 4-24. Grapnel

Northill Anchor. The **NORTHILL ANCHOR** has a stock at its crown instead of its head. Its arm is at right angles to its shank. The angle of its broad flukes assures a quick bite and penetration. The bills' sharp points cause the anchor to dig into the bottom as soon as there is a pull on the anchor line.

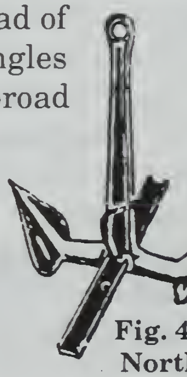


Fig. 4-25. Northill Anchor

Plow. The **PLOW ANCHOR** is of British design. It takes its name from the design of its fluke, which resembles a plow. The fluke digs in quickly and deeply when there is a pull on the anchor line. It is an efficient anchor but clumsy to handle and stow. It is used most often on large sailboats.

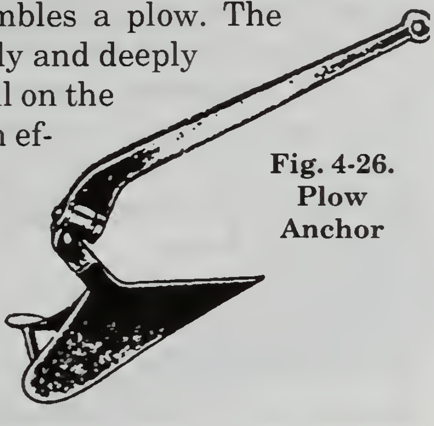


Fig. 4-26. Plow Anchor

Your Boat's Anchors

Your boat should carry at least two anchors. One anchor may be small and lightweight for easy handling. Use this **LUNCH HOOK** in good weather, when anchoring in protected areas, or for short stops while fishing. The second anchor should be larger and heavier for use such as overnight anchoring or when your boat might drag its anchor.

For cruisers, a third anchor is recommended for use in **HEAVY WEATHER**. Use this storm anchor in winds of 30 knots (34 miles per hour) or higher.

In selecting your anchor, follow the manufacturer's recommendations. Table 4-1 suggests some ground tackle sizes for use under ordinary conditions and moderate shelter from the seas. When in doubt about the correct size, use the next larger size.

Anchor Line Scope

An anchor holds best when the pull of the rode is as nearly horizontal as possible. For this reason, holding power increases as you increase the length of the rode. The **SCOPE** of an anchor rode is the ratio of its length to the depth of the water. To compute the "depth," add the distance from the water's surface to the chock the line passes through on your boat to the actual depth of the water.

Normally, a scope of 7:1 is adequate for holding a boat. This means there should be seven feet of rode for each foot of water depth. Suppose the water is ten feet deep. Suppose, too, that the chock through which the line runs is four feet above the water's surface. In this case, you need an anchor rode of 98 feet. To compute this, add the 10 feet of water depth to the 4 feet of the chock above the water's surface. When you multiply this by 7 you get 98. You need a lot of line even for a small boat in calm weather and seas!

A scope of 5:1 is marginal. A scope of 3:1 is poor unless the weather is excellent and the bottom is good for anchoring. With a 3:1 scope, you must watch your anchor at all times. A 3:1 scope is usually enough if you have stopped to eat or to fish and you stay on your boat.

A storm anchor should have a scope of at least 10:1. Even at that, you should maintain an anchor watch in stormy weather.

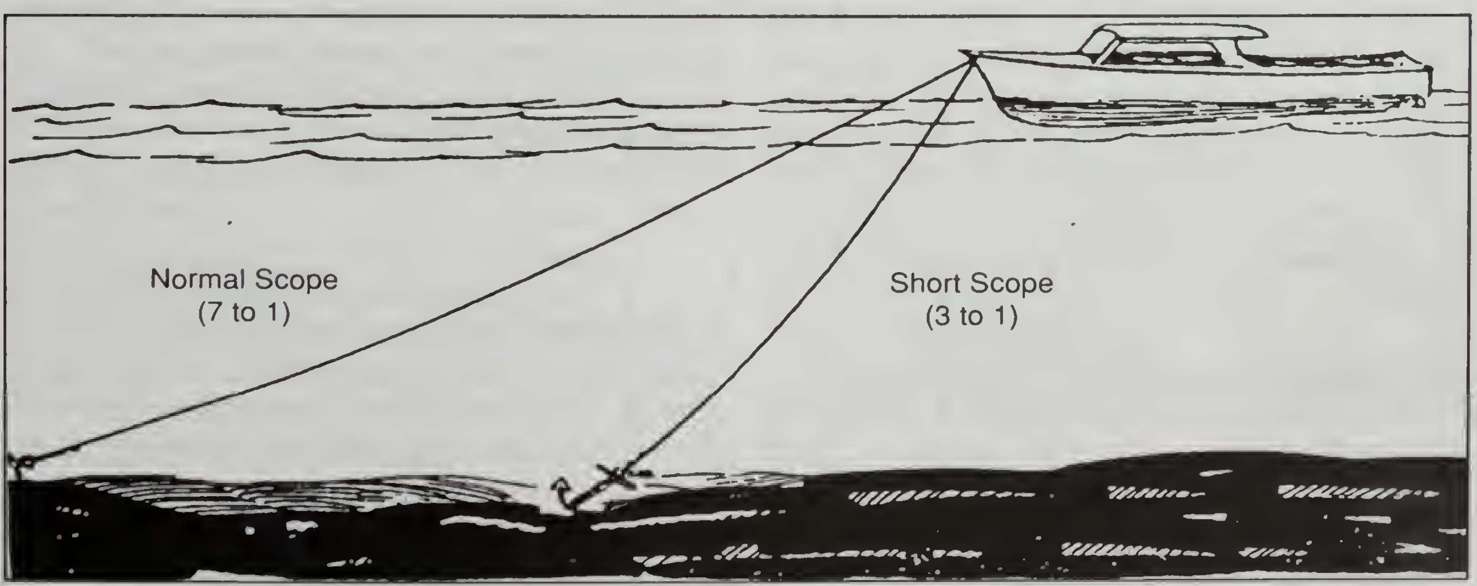


Fig. 4-27. Proper Anchoring
(Note: Drawing is not to scale.)

Anchoring

The first step in anchoring is to check the nature of the bottom and its depth. If you can't do this visually, look at your chart. It may tell you the bottom characteristics. You can also tell the type of bottom and its depth by using a lead line. A lead line is a line with a hollowed out weight at its end. The hollow contains tallow, wax, chewing gum, or bedding compound to bring up a sample of the bottom.

If the bottom is satisfactory for anchoring and the water depth is not too great, head your boat into the wind or the current. Reduce your speed and make sure your anchor rode can run freely. Reverse your engine and when the boat starts to make slight sternway, *lower* your anchor carefully over the bow. Never throw it! Make sure that you are not standing on any part of the line. Also, be careful never to drop your anchor across another boat's anchor line.

Be certain, too, that you have tied the end of the rode securely to the boat. This is the "bitter end" because it is the end you attach to a bitt. It's also the bitter end should you forget to secure it.

Table 4-1

Suggested Ground Tackle Sizes

(For Ordinary Use and Moderate Shelter from the Seas)

	Boat Size					
Item	**-15'**	**16-20'**	**21-25'**	**26-30'**	**31-35'**	**36-40'**
Danforth Anchors:						
Standard Working	4S*	8S	8S	13S	22S	40S
Standard Storm**	8S	13S	13S	22S	40S	65S
Hi-Tensile Working	--	5H	5H	12H	12H	20H
Hi-Tensile Storm	5H	5H	12H	12H	20H	35H
Plow:						
Working	5 lbs.	10 lbs.	15 lbs.	15 lbs.	20 lbs.	30 lbs.
Storm	10 lbs.	15 lbs.	20 lbs.	25 lbs.	35 lbs.	60 lbs.
Yachtsman Storm	25 lbs.	40 lbs.	50 lbs.	60 lbs.	75 lbs.	100 lbs.
Shackle, Galvanized:						
Working	1/4"	5/16"	5/16"	5/16"	3/8"	7/16"
Storm	5/16"	5/16"	5/16"	3/8"	7/16"	1/2"
Chain, Galvanized:						
Working***	1/4"	1/4"	1/4"	1/4"	5/16"	5/16"
Storm	1/4"	1/4"	5/16"	5/16"	3/8"	7/16"
Nylon Line (3-strand):						
Working****	5/16"	3/8"	7/16"	1/2"	1/2"	5/8"
Storm	3/8"	7/16"	7/16"	1/2"	5/8"	3/4"

* Data in the body of the table are anchor and other item sizes.

** For this table, winds over 30 knots (34 MPH) are considered in the storm range.

*** The proof test load (elastic limit) for chain is one-half the load at the breaking point.

**** The working load for 3-strand Nylon line is one-fifth the breaking strength and the loaded length is 1.5 times the rest length.

Take your engine out of gear, and when you have paid out enough line, make the line fast to a forward cleat or bitt. *Never* tie off to the *side or the stern* of your boat. It may be convenient but it is dangerous. Large wakes or "rogue" waves can swamp you when you are anchored from your side or stern. In a current, your boat's stern can be pushed under by the force of the moving water.

When you keep your hand on the line as you pay it out, you can tell if your anchor has dug in. When it vibrates, the anchor is sliding across the bottom. When it digs in and then skips or when it just skips, **PAY OUT** more rode until it digs in firmly. You will feel a definite halt in the drift of the boat when it digs in. When there is a current or a breeze, you will see the bow turn into it. After you have a good "bite" on your anchor, turn off your engine.

When you have finished anchoring, take sights on some stationary objects on shore (fig. 4-28). Line them up with other objects. Should your anchor drag, you can tell by checking these **RANGES**. When your anchor is dragging, let out more line.

Anchors hold best in mud, clay, or sandy mud. Hard sand is good with some anchors. Soft, loose sand is poor and in soft mud your anchor may not hold at all. Rocks can give good holding power but they may hold your anchor permanently.

Avoid anchoring in grassy areas and coral reefs. Both of these are habitats for immature marine life. If you anchor in seagrass, you damage it. Obviously, you would not want to damage a coral reef.

Be careful how much line you pay out. When the wind or the tide changes, will you swing into another boat, a buoy, a wharf, or onto the shore? Should wind or sea conditions deteriorate, check your position frequently to see that you are not dragging anchor. If you are dragging your anchor, let out more line. When this is not practical, **WEIGH** (raise) your anchor and set it again in a better location. Be mindful of the change in direction of a tidal

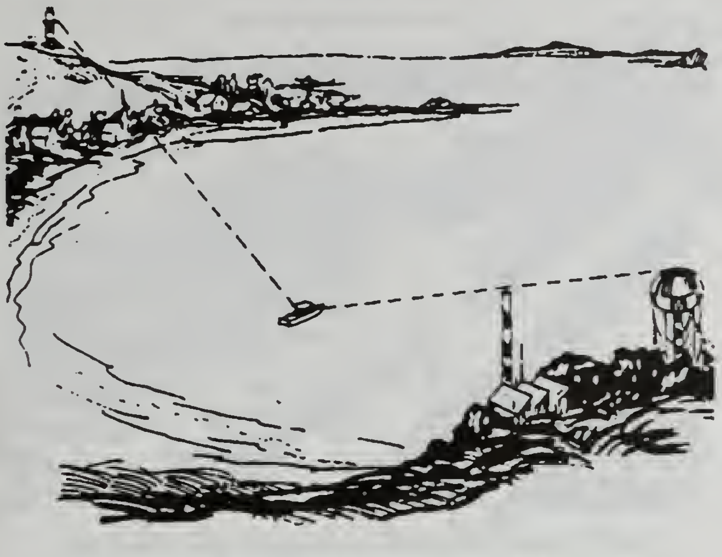


Fig. 4-28. After Anchoring, Check Position with Land Objects.

current. When the current reverses, your anchor may become fouled in its line or it may lose its hold.

Should your boat lose power in shallow water or a narrow channel, lower your anchor immediately. It may keep you from going aground.

Weighing Anchor

When you are ready to leave, go through your starting checklist, then start your engine. Be certain that it is operating properly. Then go ahead slowly to a position directly above the anchor, taking up the rode as you proceed. Usually, the anchor will break free of the bottom when you are over it. You can raise and store it.

If your anchor does not break free, it is probably fouled. Make the line fast to a bow bitt or bow cleat and run your boat slowly in wide circles with a taut line. You may be able to free the anchor.

TOWING A SKIER

When you tow a skier, use the right equipment for it. The first essential is a wide-angle rear-view mirror. In addition to the mirror, many states require that you have an observer. Even when your state does not require an observer, it makes sense to have one. The observer should be stationed so the skier is always visible to both the observer and, in the mirror, to the skipper.

Your Ski Towline

You also need a good tow-line and some place to tie it. Use the cleats or lifting rings at the stern of your boat. Better still, when you plan to make a practice of pulling a skier, equip your boat with a towing pylon, a device for centering the tow line. Mount your pylon near the boat's center of gravity. This lessens the effects of pulls to one side or the other on your boat by the skier.

Use a towline made of a synthetic fiber that floats. A floating line attached to a pylon is less likely to foul your prop. Most ski towlines are 75 feet long, but their length is regulated by law in some states. Check to see if there is such a law in your state.

Signaling

Communication between skippers and skiers is important. It is done by the hand and arm signals shown in figure 4-29. When you are the skier, place your hand with its thumb up in front of your chest to say, “Go faster.” When your thumb points down, it means, “Go slower.” A cutting motion with your hand across your throat means, “Cut the motor and stop the boat.” This signal is also used by the skipper or the observer.

To have the skipper turn the boat, raise your arm overhead with your index finger pointed upward and move your index finger in a circle. Immediately afterward, point in the desired direction.

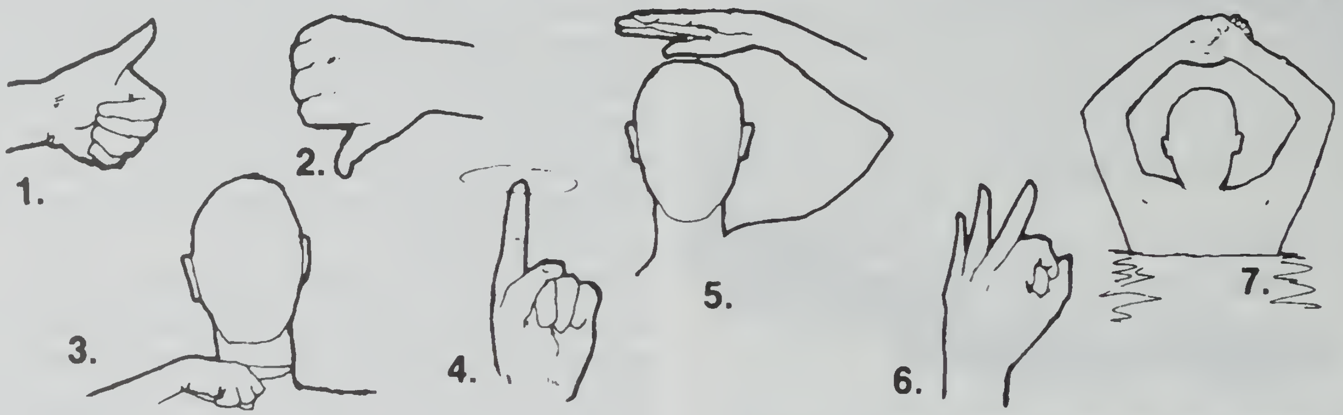
Pat the top of your head to say, “Return to the dock.” When your index finger and thumb form an “O” and the rest of your fingers point upward, you are saying “Speed and path of the boat are OK.” You use the same signal to say, “I understand your signal” in reply to a signal from the boat. After a fall, raise your clasped hands above your head to say, “I'm OK.”

Other Considerations

Skiers should always wear life jackets. This is usually a Type III. Also, when you stop to pick up a skier, ***stop your engine***. Some propellers turn over slowly even when the engine is not in gear. A running engine may accidentally shift into gear.

Make provision for retrieving your skier before you leave the dock. A dive or swim plat-

Water Skier Hand Signals



1. Thumb Up: Speed up the boat.
2. Thumb Down: Slow down the boat.
3. Cut Motor/Stop: Immediately stop boat. Slashing motion over neck (also used by driver or observer.
4. Turn: Turn the boat (also used by driver). Circle motion – arms overhead. Then point in desired direction.
5. Return to Dock: Pat on the head.
6. OK: Speed and boat path OK. Or, signals understood.
7. I'm OK: Skier OK after falling.signals understood.

Fig. 4-29. Standard Water Ski Signals
(Illustration courtesy of American Water Ski Association)

form or a boarding ladder is good for this purpose.

HEAVY WEATHER

Recreational boating is generally done in fair weather. The best advice for someone considering going out in a boat in rough weather is, "Don't." Sometimes, though, you may get caught in adverse conditions of wind and sea. Some understanding of the principles of heavy weather seamanship is helpful when this happens.

Heavy weather, in itself, does not place a small craft in danger. It is comforting to note that a well-found boat, operated by a knowledgeable skipper and an able crew, is usually equal to the task. Your boat can probably take more adverse conditions than you can.

Running into a Sea

If you move into the wind in heavy seas, the bow of your boat plows into the waves instead of lifting over them. This causes your boat to take a tremendous pounding. Your propeller alternately rises out of the water and falls back in. Thus, your engine loads one moment and races wildly the next.

Slow your boat so the bow can lift with the waves. Then, don't run directly into the waves. Instead, take them at an angle approaching 45° (see fig. 4-30). Your boat will **PITCH** and **ROLL**. That is, it will go up and down on its long axis and up and down sideways. But pitching and rolling are easier on your boat and crew than the pounding caused by going directly into the waves.

To make your desired landfall, it may be necessary to run a "zig-zag" course. Take the seas **BROAD ON YOUR BOW** for awhile and then off your **QUARTER**. Broad on the bow means between the bow and abeam. The quarter is between abeam and astern. Thus, in your zig-zag course you alternate running at an angle into the waves and running at an angle away from them. The distance you travel and the time it takes will be longer. But it beats the alternative, which is capsizing.

If you cannot make headway under these

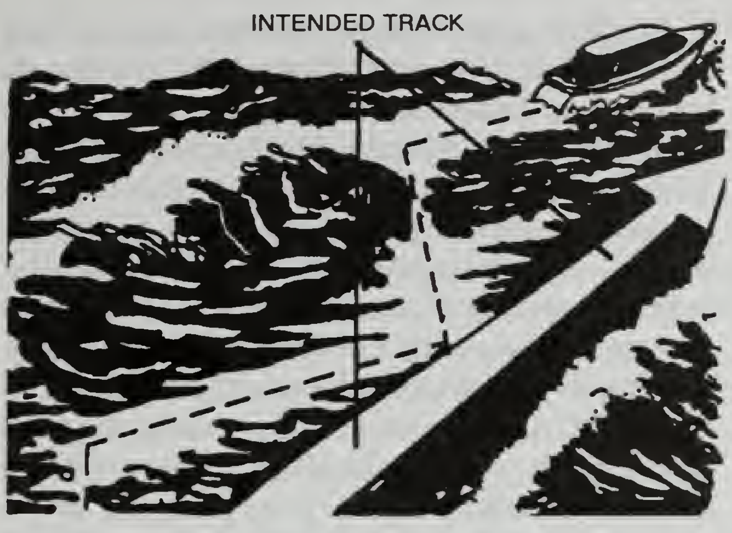


Fig. 4-30. Zig-Zagging Through Heavy Seas

conditions, it is advisable to **LAY TO**. Use enough power to keep your bow into the wind. Adjust your speed so you are making neither headway nor sternway.

Running before the Sea

A following sea moves in the direction you are going. It comes toward the stern of your boat. In deep water a following sea is not usually a problem.

In shallow bays and large shallow lakes, following seas can become dangerous for small boats with large transoms. The force of the water can cause your boat to **YAW** wildly from side to side. The greatest danger is when your boat rises on an overtaking wave. As your boat rises, its propeller comes out of the water. You no longer have control. Should your boat be yawing at the time, it may be thrown broadside into the trough and rolled over by the next wave. This is **BROACHING**.

To avoid a broach, always keep yawing under control. You can do this only by keeping your motor or outdrive in the water. When a wave lifts you and your motor or outdrive is out of the water, you have no control over your boat. Adjust your speed to stay behind the crest of the wave ahead of you and ahead of the wave behind you. Once a broach has started it is almost impossible to stop.

If you don't stay behind a wave's crest, you may find yourself racing down the forward face of the wave at a greatly increased speed. Your boat can race forward and plow into the trough, burying its bow in the water. The next wave may pick up your stern and flip your boat end over end. This is **PITCHPOLING.**

Impaired Visibility

Fog is the most common visibility impairment. Other conditions such as heavy rain, sleet, hail, snow, and dust also impair visibility. Cruising techniques are the same in all of these conditions.

The first rule for safe boat operation in impaired visibility is, "Don't go." Fog will burn off. Rain, sleet, hail, and snow will stop. Be patient. Being out on the water when the weather closes in is a whole new world that you will want to avoid if possible.

Visibility never changes instantly and without warning. Be sensitive to changing conditions. Use the time before visibility lowers to determine your position. If you don't know

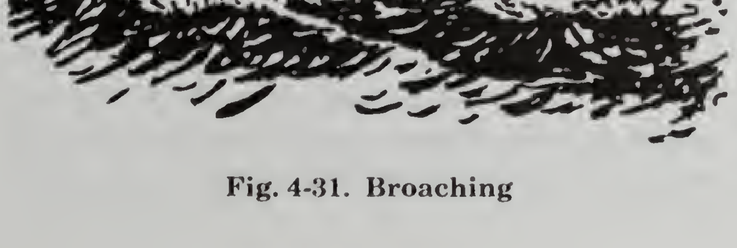


Fig. 4-31. Broaching

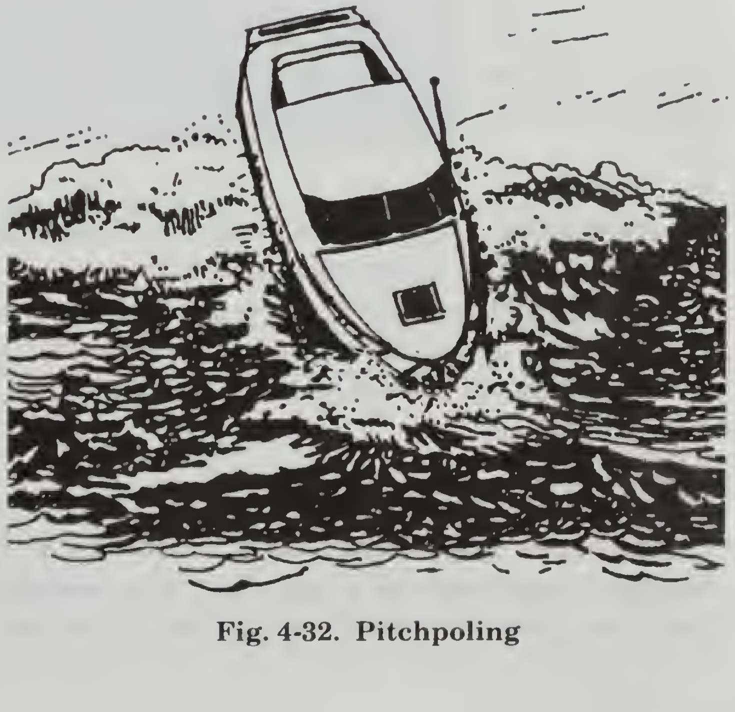


Fig. 4-32. Pitchpoling

where you are when the weather closes in, you will not know at a later time.

As the weather closes in, slow down. Determine your speed by the distance you can see. The Navigation Rules require you to be able to avoid a collision, and to travel at a "safe speed." It is your responsibility to determine what a safe speed is.

Regardless of weather conditions, the law requires that you maintain an efficient lookout when you are underway. The most frequent cause of collisions is a failure to maintain an efficient lookout. Post your lookout as far forward as possible. This keeps the lookout as far away from your engine noise as possible and makes it easier to hear sounds from other vessels.

If possible, get clear of channels and shipping lanes and anchor. If you are afraid you might go aground on the shore or elsewhere, lower your anchor. Let out enough line so it will engage the bottom before you go aground.

Narrow Inlets

Many rivers and coves connect to the sea by narrow inlets. Although no two are alike, they have a lot in common. Unlike shoaling along a coast, at the mouth of most narrow inlets shoaling is rapid and continuous. Furthermore, sand bars shift rapidly making it difficult to mark channels with buoys.

It is not possible to learn how to run *narrow and breaking* inlets from a book. They come in all sizes and shapes. Some should be run only by experts even under the best of conditions. Others may present only minimal problems at times. At other times they may require a high degree of skill.

Get Advice

No prudent skipper would try the first run of an unfamiliar inlet without having a "native" aboard. The native can point out known hazards and show where the safe channel is probably located. Before you try to run an inlet, get local advice.

SMALL BOAT SAFETY

If judged by the number of accidents and fatalities reported each year, and the limited time that boaters actually spend on the water, boating would seem like a dangerous sport. But boating is exciting, refreshing and a lot of fun if proper precautions are taken.

Contrary to popular belief, boating accidents do not always occur on large bodies of open water. Nor do they always happen to people who see themselves as boaters. The victim of a boating accident is most often a man between the ages of 24 and 34 fishing on a quiet lake on a Saturday afternoon. Often the victim is a hunter. These people were not really boating; they considered their boats to be part of their hunting or fishing gear.

People who fish or hunt frequently use small boats, 12 to 14 feet or less in length. Such boats are generally safe but can be unstable and may be dangerous under some circumstances. If you stand up in one, it may capsize. If it is overloaded, it may easily swamp, especially in adverse weather and water conditions.

Although the boat may be unstable, its occupants may stand up and move about to land a fish, to shoot a duck, to exchange positions in the boat, to relieve themselves, or for other reasons. One of them may fall overboard or their movements may cause the boat to capsize, and they may all end up in the water. If they are not wearing life jackets, they may be in serious trouble.

Many people who drowned under similar circumstances were good swimmers. But the sudden plunge into cold water may disorient them. They may hit their heads on the boat as they fall in and be rendered unconscious. They may be seriously injured by the boat's propeller and unable to care for themselves. ***Wear your life jacket at all times***. The smaller the boat, the more important it is to observe this rule.

Hunters often overload their boats. Ordinarily, they do not get weather checks to learn water and wind conditions. What was a safe load in favorable weather conditions may not be safe with approaching poor weather. Hunting seasons are usually periods of changing weather. These changes may be sudden and violent.

In a fatal accident that occurred several years ago, two duck hunters launched a small, aluminum boat at a ramp in a sheltered cove about an hour before sunrise when the wind was calm. They carried two shotguns, ammunition, 20 decoys with lead weights, lunches, a thermos of hot coffee, a 50-pound Labrador retriever, two life jackets (which they were not wearing), extra fuel, and a 15 horsepower outboard. Each man weighed about 180 pounds.

Although heavily loaded, the boat was not overloaded for the water and wind conditions in the cove. As they turned into the river and headed upstream, however, they met a brisk breeze. Since this stretch of the river was short and the wind was blowing across it, surface conditions were fairly calm.

At the first bend in the river, they headed directly into the wind. The combination of the river current and the wind blowing downstream raised considerable spray. Suddenly, they found themselves in a dangerous situation. They turned the boat to return to the cove. Unfortunately, when the boat's beam turned to the waves and the wind, it swamped. One man drowned.

Many other incidents could be cited but they all teach the same lessons:

- If you move about in a small boat, keep as low as possible. Better still, avoid moving about.
- Wear your life jacket under all conditions.
- Get a weather report before you launch your boat.
- Keep a “weather eye” peeled for changing conditions.
- Load your boat with current and anticipated weather conditions in mind, but never overload it.

Fig. 4-33. Boat Capsized in an Inlet
(Courtesy BOAT/U.S.)

APPLY TODAY

MEMBERSHIP IN THE AUXILIARY IS YOUR KEY TO A LIFETIME OF SAFE BOATING

The United States Coast Guard Auxiliary is one of the premier boating safety organizations in the world.

PURPOSE OF THE AUXILIARY

The purpose of the Auxiliary is to assist the Coast Guard, as authorized by the Commandant of the Coast Guard, in performing any Coast Guard function, power, duty, role, mission, or operation authorized by law.

U.S. citizens 17 years old or older who have at least 25% ownership in a boat, airplane, land or mobile radio station or a special skill needed by the Coast Guard may join the Auxiliary.

The Auxiliary was authorized in 1939 by an Act of Congress. It is composed of unpaid, volunteer U.S. citizens who own boats, airplanes, radio stations, or have special skills.

Your instructor or any other Auxiliarist will help you become a member of this volunteer group

5

Your "Highway" Signs

The first sailors rarely left sight of land. Their only navigational aids were familiar landmarks. Later, they took long voyages out of sight of land with only crude instruments, the sun, and the stars to guide them. Today, we still depend on visible landmarks. But there are also many more sophisticated aids to navigation.

An **AID TO NAVIGATION (ATON)** is a device designed to help you determine a safe course and where you are. Short range aids to navigation include **BUOYS, DAYBEACONS, MINOR LIGHTS,** and **LIGHTHOUSES**. Long range aids include **LORAN, RADIOBEACONS**, and **SATELLITE BEACONS**.

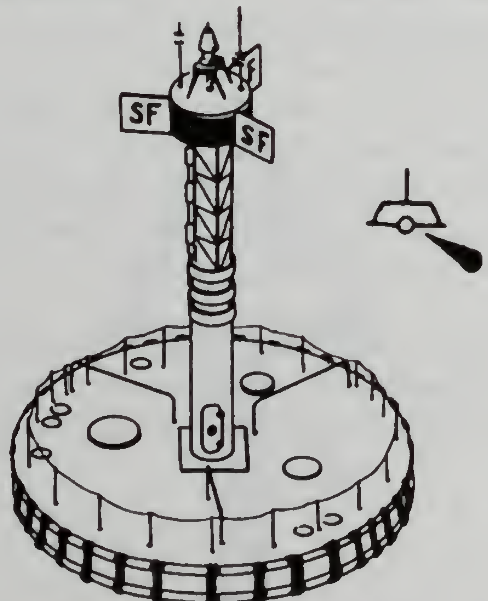


Fig. 5-1. A Large Navigational Buoy and It's Chart Symbol

ATONs are shown on nautical charts. With caution, a good chart, and knowledge of ATONs, your boating can be safe and enjoyable.

Although *not* ATONs, prominent structures and natural objects can help you pilot your vessel. These include church spires, radio towers, water tanks, mountain peaks, promontories, and other landmarks. To be useful as ATONs, landmarks must be visible from the water and they must appear on charts of the area.

PROTECTION OF ATONs

All ATONs are protected by law. It is a criminal offense to damage an ATON or to hinder its proper operation. Do not alter, deface, destroy, or move an ATON. Never tie up to one, and avoid anchoring so close to one that it is obscured from the sight of passing boaters.

BUOYAGE SYSTEMS

Most ATONs are grouped in **BUOYAGE SYSTEMS**. This name comes from one of the principal markers in the system--buoys.

The United States uses four principal buoyage systems. They are:

1. the **U.S. AIDS TO NAVIGATION SYSTEM**,
2. the **INTRACOASTAL WATERWAY MARKING SYSTEM (ICW)**,
3. the **WESTERN RIVERS SYSTEM**, and
4. the **UNIFORM STATE WATERWAY MARKING SYSTEM (USWMS)**.

U.S. Aids to Navigation System

The principal buoyage system used in the United States is the U.S. Aids to Navigation System. This system conforms to the Region B standards of the International Association of Lighthouse Authorities. Boaters traveling outside the United States may see ATONs that vary from those in this chapter. You should consult appropriate charts and publications if you are boating in foreign waters.

The U.S. ATON System uses buoys, beacons, and minor lights as marks. These mark obstructions, dangers such as wrecks, the sides of navigable channels, and other things of importance to mariners. The U.S. Coast Guard maintains the marks in the system.

The U.S. ATON System has six types of marks or ATONs. These are

1. **LATERAL MARKS**, including **PREFERRED CHANNEL MARKS,**
2. **SAFE WATER MARKS**,
3. **ISOLATED DANGER MARKS**,
4. **RANGE MARKS,**
5. **REGULATORY MARKS**, and
6. **SPECIAL MARKS.**

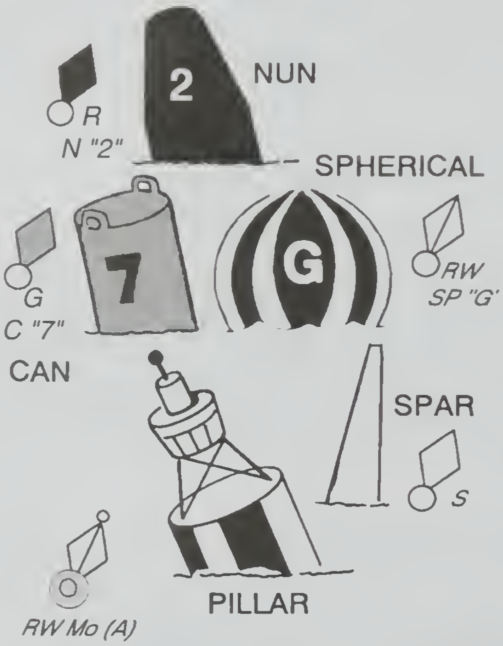


Fig. 5-2. Buoy Shapes and Their Chart Symbols*

Marks used in the U.S. ATON System and their chart symbols appear in Plate 1 inside the back cover of this book. They are discussed below.

Intracoastal Waterway

The Intracoastal Waterway (ICW) runs south from Manasquan Inlet in New Jersey to the Florida Keys. It then runs north along the west coast of Florida and west along the Gulf coast to Brownsville, Texas. The U.S. Army Corps of Engineers maintains the ICW. Wherever possible, the ICW runs through protected bays, sounds, and canals. It also takes maximum advantage of the protection given by offshore islands. Marks on the ICW are similar to those of the U.S. ATON System.

The ICW uses marks to show you the limits of navigable channels, preferred channels, safe water, and ranges. The system also includes marks with no lateral significance. The U.S. Coast Guard maintains the ICW marks. You can see the ICW marks in the upper portion of Plate 2 at the back of this book.

Western Rivers

The meaning of the term **WESTERN RIVERS** may surprise you. "Western Rivers" includes the Mississippi River, its tributaries, South Pass, Southwest Pass, and the Port Allen-Morgan City Alternate Route. It also includes the Atchafalaya River above its junction with the Port Allen-Morgan City Alternate Route, the Old River, and the Red River.

You do not need to know this definition unless you boat along the lower Mississippi River. Otherwise, all you need to know is that the Western Rivers include the Mississippi and its tributaries. Chapter 12 on Inland Boating includes a discussion of Western Rivers ATONs.

The U.S. Coast Guard maintains the marks on the Western Rivers. You can see these marks in Plate 4 at the back of this book.

---

[*] Most ATONs are red or green or a combination of red and green. In the illustrations, we have used solid black to depict red and dotted black to show green in-so-far as is practicable. The plates in the back of this book show the correct colors of the ATONs.

Uniform State Waterway Marking System

The marks of the Uniform State Waterway Marking System (USWMS) are similar to those of the U.S. ATON System. There are significant differences, though. State boating authorities maintain the USWMS marks. You can read about the USWMS in chapter 12 on Inland Boating. Marks in this system are shown in the bottom portion of Plate 4.

WATERWAY MARKS

Waterways have a variety of buoys, daybeacons, and fixed structures. The variety stems from the purposes they serve.

Buoys

Buoys are floating ATONs. They may have lights. They mark navigable channels, isolated dangers, obstructions, or shoals. When a buoy has a light, it shines from dusk to dawn. It turns on automatically and is not on during daylight hours. Solar energy charges many of the batteries that power these lights. There are five common types of buoys (see fig. 5-2).

Floating Structures

Some buoys are floating *structures* called pillar buoys. These vary considerably in shape, size, and function. They range in size from very small ones to large, floating lighthouses. Buoys may have lights, bells, gongs, whistles, fog horns, or combinations of these devices. The larger structures are multi-functional. They have lights, radio beacons, and, sometimes, radar beacons. They may also have weather recording and transmitting equipment.

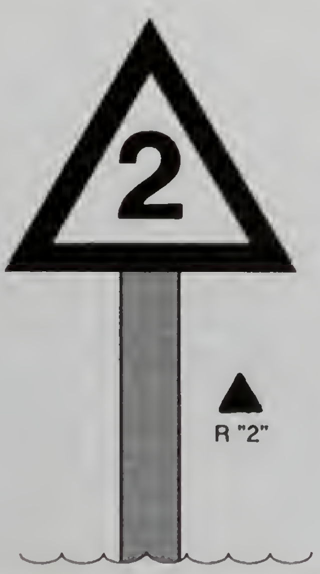


Fig. 5-3. Red Daymark on a Piling

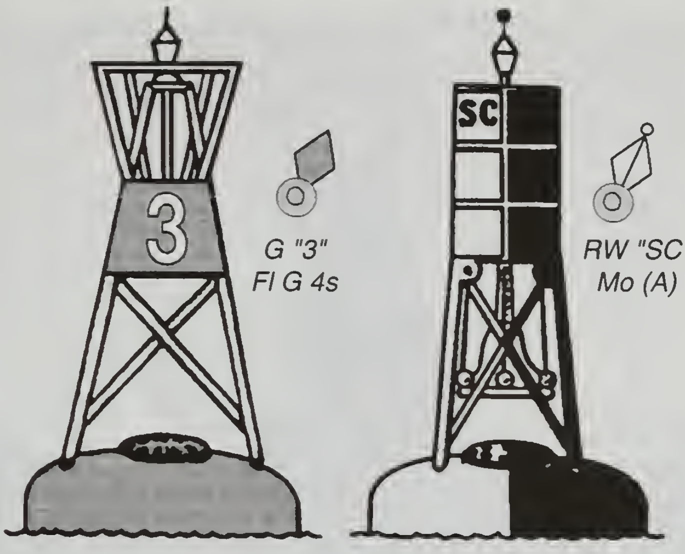


Fig. 5-4. Pillar Buoys

Spherical Buoys

A second shape for buoys is spherical. Spherical buoys are red and white striped (fig. 5-5). They mark a **FAIRWAY** or the middle of a channel. Fairways are parts of **TRAFFIC SEPARATION SCHEMES**. Traffic Separation Schemes are “one-way traffic lanes” used in some harbors and other congested areas.

Nun and Can Buoys

The two most common buoys are **CANS** and **NUNS** (figs. 5-2, 5-6, and 5-7). In the U.S. ATON System, a *can* most often is a green colored, cylindrical buoy. It has an odd number on it.

A *nun* buoy has a conical shaped top, with its point cut off. In the U.S. ATON System, it is most frequently red and has an even number on it. Nun and can buoys mark the sides of navigable channels.

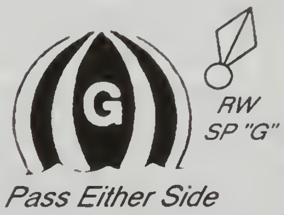


Fig. 5-5. Vertically-Striped Safe Water Buoy

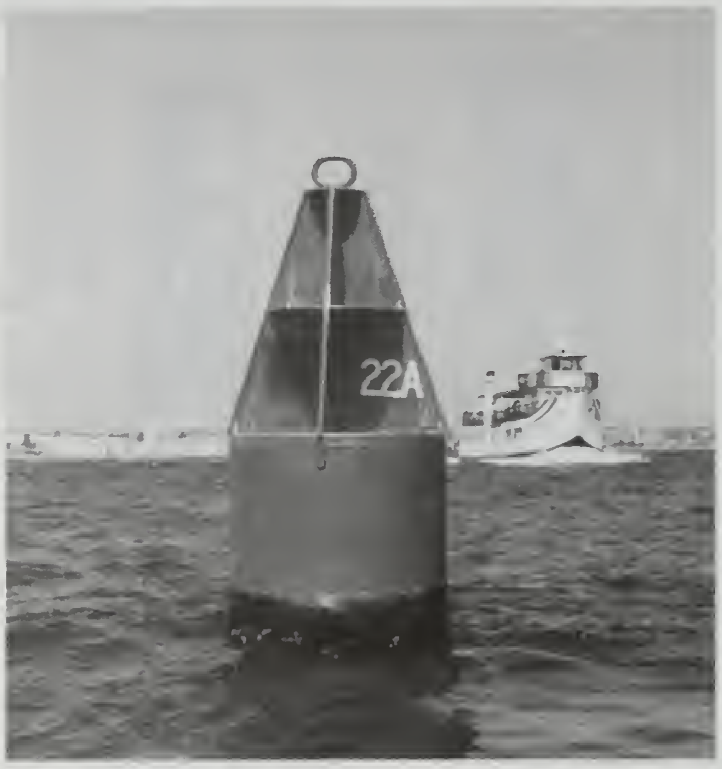


Fig. 5-6. A Red Nun Buoy

Spar Buoys

SPAR BUOYS are the fifth type of buoy (fig. 5-2). They are similar in shape to sections of telephone poles although they may be much smaller in diameter. They may be red and even numbered or green with odd numbers. The U.S. ATON System does not use spar buoys nor are they used on the ICW, the Western Rivers, or other navigable waters. They are used in the Uniform State Waterway Marking System.

Be Cautious Around Buoys!

When navigating near buoys, use caution. They are at anchor! Just like a vessel, they drift around their anchor positions with wind or current in what is called a **WATCH CIRCLE**. They may even drag their anchors and be out of their charted positions. For this reason, the location of a buoy on a chart is sometimes marked PA. PA means position approximate.

Worse still, many conditions cause buoys to be "off-station." These include wind, ice, flooding, accidents, and others. A buoy may be off station after a vessel collides with it. An accident may cause it to be missing.

The lights on normally lighted buoys may be extinguished and sound producing buoys may not make their sounds. Sound buoys are helpful ATONs but in a fog, when you need them the most, they may not work. Waves and swells make some whistles, gongs, and bells produce sounds. In a fog the sea may be calm and the buoys silent.

Daybeacons

DAYMARKS are colored geometrical shapes. They may be triangles, squares, octagons, diamonds, or rectangles. A daybeacon is a daymark plus the pile or **DOLPHIN** that holds it. A dolphin is a group of three or more piles, usually fastened together with a wire rope.

Triangular Daymarks

Triangular daymarks are equilateral triangles (fig. 5-3). This means that their three sides are the same length. They rest on their bases. Generally, these daymarks are red and, when numbered, have even numbers. (Interestingly, the daymark with an odd number of sides displays an even number.)

Square Daymarks

Generally, square daymarks are green and, when numbered, have odd numbers (fig. 5-8). (Even though they have an even number of sides they have odd numbers.)

Fig. 5-7. Coast Guard Servicing a Green Can Buoy (left) and a Red Nun Buoy (right).

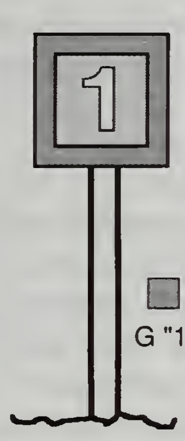


Fig. 5-8. Green Daymark With Dark Green Border on a Pile

Diamond Shaped Daymarks

There are two kinds of diamond shaped daymarks. One of these is used in the U.S. ATON System, and on the ICW, Western Rivers, and other navigable waters. These ATONs may have white lights. Inside each diamond are two smaller colored diamonds. These inner diamonds may be, orange, green, or black (fig. 5-9). These daymarks are like the "Xs" on shopping mall maps. They show, "You are here." When you find the daymark on a chart, you know where you are. You can see examples of these daymarks in the plates at the back of this book.

The second type of diamond shaped daymark is called a crossing daymark and is found on the Western Rivers and other navigable rivers. Crossing daymarks are discussed in chapter 12 on Inland Boating.

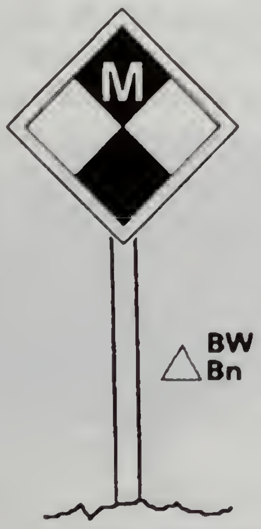


Fig. 5-9. Diamond Shaped Daybeacon with No Lateral Significance

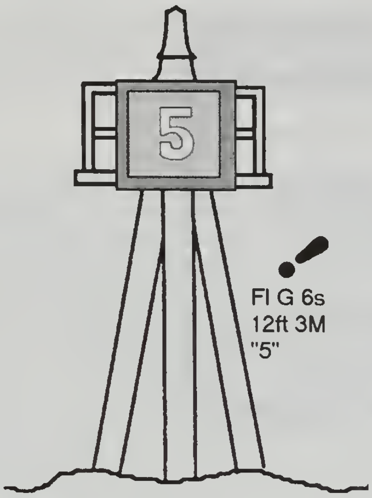


Fig. 5-10. Minor Light with a Daymark on a Dolphin

Light Structures

Lighted ATONs vary greatly in size. They may be simple battery powered minor lights on wooden piles or dolphins or they may be tall lighthouses with powerful lights.

Light structures have the same functions as buoys. They are used, however, where they perform more suitably than lighted buoys. A minor light, for example, may mark the mouth of a channel.

Minor lights are red, green, or white. They also have daymarks. If the light is red, the daymark is a red triangle with an even number. If the light is green, its daymark is a green square with an odd number. And if the light is white, its daymark is diamond or octagonal shaped and may have a letter.

Informational and Regulatory Marks

Informational and regulatory marks may be either buoys or rectangular daymarks with orange borders. Informational buoys are white cylinders. Each buoy has an orange band near its top and a second orange band just above its water line. The buoy also has a diamond or a circle on it. These daymarks and buoys are shown in Plates 1 and 4 inside the back cover of this book.

An open diamond on a board or buoy warns of "Danger." If the diamond has lines connecting its opposite corners, it marks an exclusion area for boats. Stay out! This mark frequently guards a swimming area. An open circle on a board or buoy means restricted operations such as "slow," "idle speed," or "NO WAKE." The warning is usually printed within the circle.

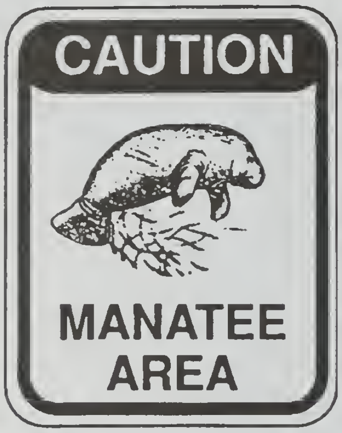


Fig. 5-11. Manatee Caution Mark

One **INFORMATIONAL MARK** needs special emphasis. This is a sign that says, "Caution, Manatee Area." South Florida has many of these marks. They seek to protect the manatee, an endangered mammal that is especially vulnerable to injury by small boats. If you see the sign, slow to idle speed.

Examples of typical informational and regulatory marks appear on the bottom left portion of Plate 1 at the back of this book.

Marks for Special Purposes

Special purpose marks are yellow and may have letters. When lighted, they have amber (yellow) lights. They may be can or nun buoys, diamond daymarks, or small floating structures.

Special purpose ATONs mark things such as fish net areas, spoil grounds, military exercise zones, and anchorage areas. They also mark Traffic Separation Schemes when conventional channel marking would be confusing. You can find examples of these special marks in the lower, right side of Plate 1.

HOW WATERWAYS ARE MARKED

Waterway marks fall into two groups. Marks in one group help you operate in navigable channels. Marks in the second group show special conditions.

Marks on Navigable Waters

Marks on the navigable waters of the United States (except Western Rivers and the Intracoastal Waterway) appear in Plate 1. Those ATONs that help guide you along channels are shown in the upper one-half of the Plate. To understand their use, you need to know a principle called "Returning from the Sea" or "Red, Right, Returning."

Red, Right Returning!

A basic convention of ATON usage is the concept *returning from the sea or Red, Right Returning.* This means that you must always keep red buoys and marks on your starboard side as you return from the sea. Green ones should be on your port side.

What "returning from the sea" means is obvious when you enter a channel that leads from the sea. In other cases it is more arbitrary. By agreement, when you go in a *clockwise* direction around the United States, you are "returning from the sea." Thus, going south along the east coast of the U.S., continuing north along the west cost of Florida, west along the Gulf coast, and north along the west coast of the U.S. is "returning from the sea."

On the Intracoastal Waterway, when you go south from Manasquan to the Florida Keys, north along the west coast of Florida, and west along the Gulf Coast, you are "returning from sea."

Less arbitrary is "returning from the sea" in the St. Lawrence River and the Great Lakes. Going up the St. Lawrence from its mouth toward its source is "returning from the sea." For the Great Lakes, the outlet ends are the seaward ends. Going up any river is "returning from sea."

Within a body of water such as a bay or a sound, channels leading to docking or mooring areas follow the same convention. When you

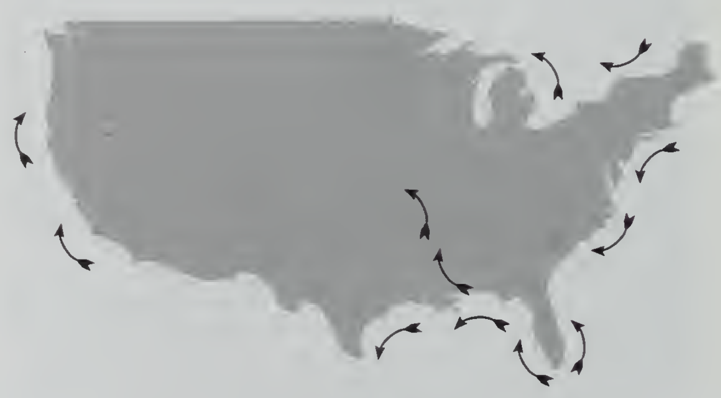


Fig. 5-12. Red, Right, Returning Conventions

are returning to a docking or mooring area, you are "returning from the sea." So, you don't even need to have been "to sea" to be returning from it.

Lateral Marks on Navigable Waters

The ATONs that mark the sides of navigable channels are called lateral marks. They consist of lighted and unlighted buoys, daybeacons, and minor lights. They have distinctive colors and numbers.

The marks you keep on your starboard side when returning from the sea are red and have even numbers. "Red, Right, Returning" means, "Keep the red marks to your starboard when you return from sea." Those you keep to your port side are green and have odd numbers. When lighted, red marks have red lights and green marks have green lights.

The upper one-half of Plate 1 is as seen entering from seaward. The "seaward" end is the lower end of this section. Keep the ATONs on the left side of the plate to your port as you return from seaward. When "returning from the sea," keep the ATONs on the right side of the Plate to starboard.

A word of caution is in order. When you are "going to sea," keep green marks to your starboard and red ones to port.

Numbers on Lateral Marks

The numbers on lateral aids are in sequence. As you enter a waterway from seaward you meet the buoy, daybeacon, or minor light with the lowest number on the waterway. Usually, this is number 1 and it will be a green lighted structure, a green buoy, or a green daybeacon. Keep this mark on your port side as you pass it. The first mark may, instead, be a red ATON with an even number. If so, keep it to your starboard side.

Marks occur in pairs only where needed. When marks are paired, opposite a green mark will be a red mark and it usually will have the next higher number. For example, if there is a red daybeacon paired with daybeacon 5, it usually will be number 6.

The numbers on marks are always in sequence although some numbers may be missing. Too, you may find marks with a number and a letter such as 5A. The letter shows that the mark was added after the original series was set up. Your chart will tell you which numbers mark the waterway and the locations of the ATONs.

***If a daybeacon appears on your chart and if you do not see it, be careful!* A collision may have broken it off. Its remains, especially its stump, may still be there. If so, it is a hazard.**

Safe Water ATONs

Safe water ATONs are spherical buoys, floating structures with balls attached to their tops, or octagonal daybeacons. They are red and white and *vertically* striped (fig. 5-13). When lighted, they have white lights. Safe water ATONs may have letters but they never have numbers. The middle part of the upper portion of Plate 1 shows the "safe water" marks seen in fairways or in midchannel.

Preferred Channel Marks

Preferred channel marks are found at junctions of navigable channels (fig. 5-14). They show you the preferred channel. They may also mark wrecks or obstructions. You may pass on either side but you should consult your chart to find the location of the obstruction.

Preferred channel marks are daybeacons, nun and can buoys, and floating structures. Their special features are their red and green *horizontal* color bands. As with safe water

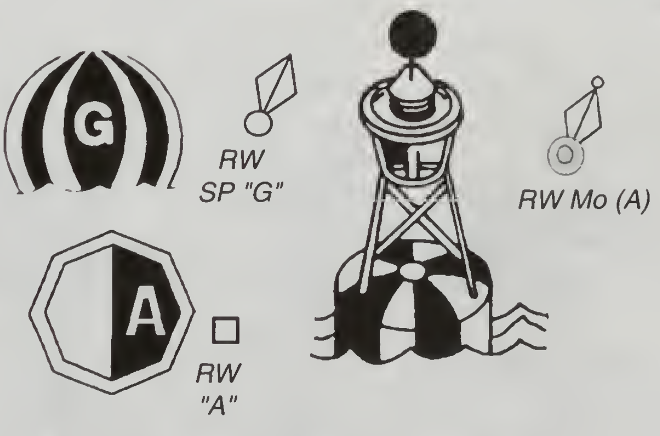


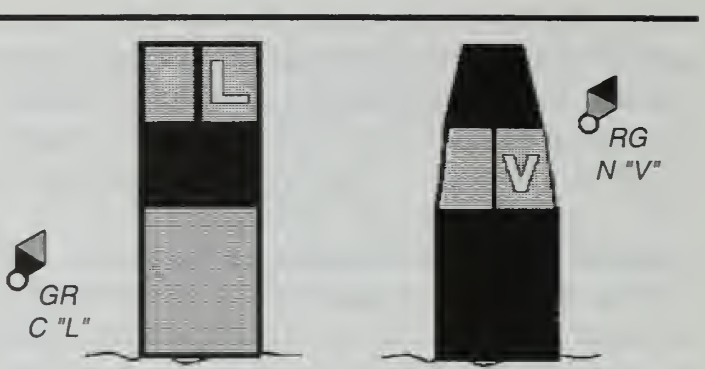
Fig. 5-13. Vertically-Striped Safe Water Buoys and Their Chart Symbols

marks, these ATONs may have letters but do not have numbers. Thus, marks on the sides of channels have numbers and marks within channels have letters.

The color bands on a preferred channel mark help you know which is the main or preferred channel. The main channel has the deepest water. When the top band of the mark is red, treat it as if it were a red mark in order to stay in the preferred channel. Keep it to your starboard as you pass it while returning from sea. When the top band is green, treat it like a green mark in order to stay in the preferred channel.

If the preferred channel mark is a can buoy, its top color band will always be green. If it is a nun buoy, its top color will always be red. So, if at a junction point you see the shape of the buoy, you don't even need to see the color of its top band. If it is a can, keep it to your port when returning from the sea. If it is a nun, keep it to starboard when you return.

Preferred channel marks may have lights. If so, the color of the light will be the same as the color of the top band. When the top band is red, the light will be red. When green, the light will be green. At night when you know you are at a junction, you don't even have to see the mark to know which is the preferred channel. All you need to see is its light. Preferred channel marks appear beneath the safe water marks on Plate 1.



CAN
(To stay in the preferred channel, keep this buoy to your port when you return from sea.)

NUN
(To stay in the preferred channel, keep this buoy to starboard when returning from sea.)

Fig. 5-14. Buoys Marking Preferred Channels and Their Chart Symbols

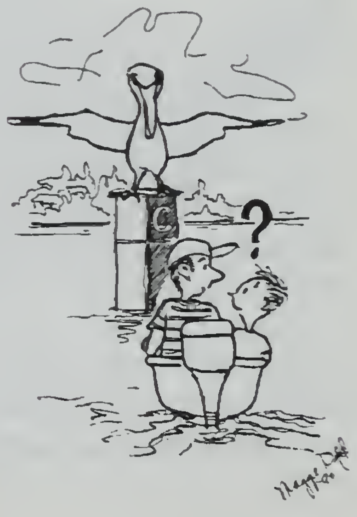
Ranges

Ranges are pairs of ATONs (figs. 5-15 and 5-16). When you see them in a line, your vessel is in the center of a navigable channel. Ranges appear in a variety of colors and may have letters. They never have numbers.

The two ATONs in a range are placed a suitable distance apart, and the rear one is always higher than the forward one. If you veer to the left of the channel's center, the forward mark appears to the right of the rear one. If you are to the right of the center of the channel, the forward one appears to the left of the rear one. To correct your course, steer in the direction of the closer (lower) mark.

Range marks often have red, green, or white lights to serve as guides at night. You use the lights in the same manner as the range. Keep them in line and you will be in the middle of the channel.

Always consult your chart when using a range. The marks help you stay in the middle of the channel. They do not tell you how far you can follow the range before the channel ends or turns. Range marks are often on land, a poor medium in which to operate your boat. Range marks are shown in Plate 1.



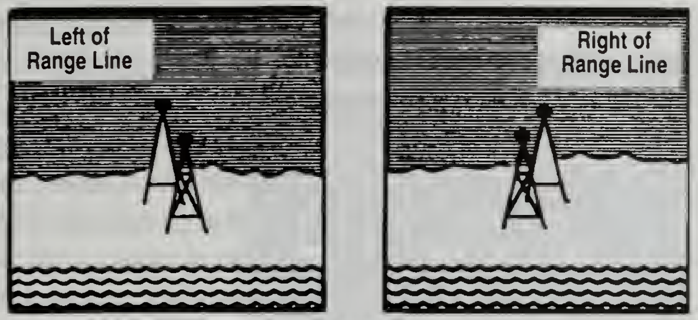


Fig. 5-15. Off Range—Not in Center of Channel

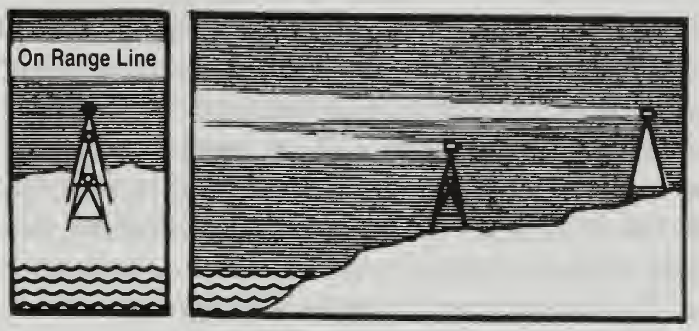


Fig. 5-16. On Range—in Center of Channel

Directional Lights

DIRECTIONAL LIGHTS may be used where it is not practicable to install range lights. (Directional lights do not appear on any of the plates.) A directional light is placed at one end of a straight section of a channel. It is high enough to be seen the full length of the channel.

This single light produces a high-intensity, narrow width beam of white light. On either side, through separate lenses, are broader red and green sectors. The red and green sectors are on the same sides of the channel as the red and green ATONs. Your chart will show you the arcs covered by each sector.

When you see only the white light, you are in the center of the channel. If the red light is visible while you are returning from sea, you are to the right of the channel's center. If the green light is visible, you are to the left of the channel's center.

Even though an area is marked with ranges or directional lights, it may not be necessary or advisable for you to follow them. In harbors, for example, the water is usually deep enough outside marked channels for small boats to navigate safely. If there is commercial traffic in the channel or if the channel or the harbor is congested, consult your chart to see if you can safely navigate outside the channel. If so, get out of it.

Daymarks with No Lateral Significance

Some daymarks have no lateral significance. They do not mark the sides of navigable channels. Neither do they show the middle of a channel nor a preferred channel. Their sole purpose is to help you determine where you are. You can see these diamond shaped "You Are Here" daymarks on Plate 1.

Intracoastal Waterway Marks

ATONs on the Intracoastal Waterway are the same as those on the navigable waters of the United States with one exception.

Yellow Triangles, Squares, and Bands

All lateral marks on the ICW have yellow, reflective triangles or squares on them. Generally, red daymarks, buoys, and minor lights have yellow triangles. Yellow squares generally appear on all green ones.

When you follow the ICW south from Manasquan, NJ, around Florida, and west along the Gulf Coast, keep daybeacons, buoys, and minor lights with yellow triangles to starboard. Keep ATONs with yellow squares to port.

Non-lateral ICW ATONs, such as safe water marks and ranges have yellow bands.

Intracoastal Waterway (ICW) ATONs can be seen in the upper one-half of Plate 2.

Dual Purpose Marks

There is a possible point of confusion. Where the ICW joins or crosses another waterway, you will find the yellow ICW triangles and squares on the marks of the crossing waterway. Thus, it is possible to have a yellow triangle on a green, square daymark, a green buoy, or a structure with a green light. Too, you can find a yellow square on a red, triangular daymark, a red buoy, or a structure with a red light. When you do, interpret the meaning of these dual purpose marks according to whether the yellow mark is a triangle or a square if you are on the ICW.

There is a logical explanation for this somewhat confusing situation. When the ICW was constructed, the engineers used existing waterways wherever possible. Many of those waterways already had lateral marks in place. Rather than add more marks to identify the ICW, reflective triangles or squares were added to the existing marks. Thus, each mark now serves a dual purpose in that it aids boaters on the ICW as well as those traveling on the original waterway.

The best way to avoid confusion when you see these dual purpose ATONs is to remember that if you are following the ICW, be guided only by the yellow triangles and squares. Ignore the colors and shapes of the ATONs on which they appear. If you are following the original waterway, be guided by the colors, shapes, and numbers of the original ATONs. Ignore the yellow triangles and squares.

The upper portion of Plate 2 illustrates how you should interpret these dual purpose marks. First, note that the ICW is the dotted line going from the upper right of Plate 2 to its upper left. The crossing waterway is shown by the heavy black line.

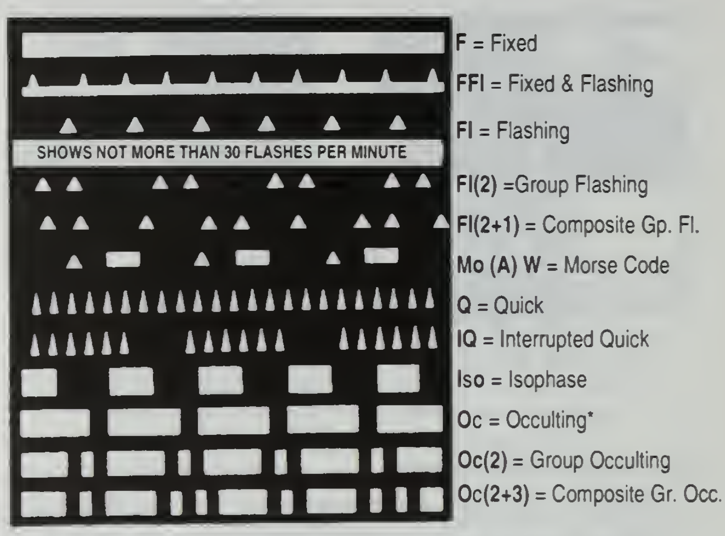
When you are travelling on the ICW from right to left in the upper part of Plate 2, you are considered to be returning from sea. As you would expect, red nun buoy “2” has a yellow triangle on it. Keep it to your starboard. Green can “3” has a yellow square on it. Keep it to port.

When returning from sea you might expect to keep red buoy “6” to your starboard. Since you are on the ICW, though, and returning from seaward, you are guided by its yellow square and keep the buoy on your port side. Red buoy “8” has a yellow triangle. You keep it to your starboard. On the ICW, you are guided by the yellow square or triangle, not by the colors or shapes of the ATONs on which they are placed.

LIGHT CHARACTERISTICS

Generally, lighted ATONs on the starboard side of a channel as you enter from seaward have red lights. Those on the port side generally have green lights. Thus, red ATONs have red lights, when lighted, and green marks have green lights.

Most ATONs used for navigational purposes do not have white lights except on the Western Rivers System above Baton Rouge. Informational, regulatory, and diamond shaped marks that have no lateral significance, have white lights when lighted. White lights are on safe water and range marks, however, and here they serve navigational purposes.



* Note: On occulting lights, use the dark portion to determine their patterns.

Fig. 5-17. Light Patterns

Light Patterns

Most lights on ATONs have flashing patterns of illumination to help you identify them. Some lights, though, are “fixed.” A **FIXED LIGHT** shines continuously from sundown to sunup.

Lights flash in a large variety of ways. They may flash on or off or they may have groups of flashes. For example, a light may flash on twice and then be off for a short period of time. It may, instead, flash at regular intervals. If it flashes every four seconds, its period is 4 seconds. A **“QUICK” LIGHT** flashes 60 times per minute. Its period is 1 second. The lower range light in the middle of Plate 2 is a quick light. Figure 5-17 shows several of the light patterns in use. Plate 1 shows them in color.

Occulting Lights

A light can also occult. A **FLASHING LIGHT**, flashes *on* while an **OCCULTING LIGHT** blinks *off*. A flashing light is off more than on and an occulting light is on more than off. Lights can also occult with regular patterns. An “isophase” or “iso” light is on for an interval equal to the time it is off. (“Iso” is from the Greek “isos” which means equal.) The upper range light in the middle of Plate 2 is an isophase light. Red buoy 4 in the middle of the Plate has an occulting light.

Safe Water ATON Lights

The white lights on safe water marks flash a regular pattern of a short flash followed by a longer one. A period of darkness follows these two flashes. The light is flashing the Morse code letter "A" (• —). Any light that flashes "A" is a safe water mark. The light on the red and white striped buoy at the bottom of Plate 2 flashes a dot followed by a dash.

Preferred Channel Lights

The light on a preferred channel mark is either red or green. Its color matches the color of the top band on the ATON. Whatever its color, it always flashes in a set pattern that means, "I am a preferred channel light." This pattern is two flashes followed by a brief period of darkness after which it flashes again. The period of darkness after the single flash is longer than the one following the two flashes. After this period of darkness, the light again flashes twice and then once. Lights that flash in this manner are called composite group flashing lights. The particular sequence described here is 2 + 1, that is, two flashes followed by one flash. Can you find the preferred channel buoy on Plate 2?

Articulated Lights

An **ARTICULATED LIGHT** is a combination of a minor light and a buoy. It is a sealed hollow cylinder, up to 50 or more feet long. It attaches to a buoy "sinker" or anchor at its lower end by means of a swivel. The cylinder floats in a vertical or nearly vertical position. Sometimes, the cylinder has an additional buoyancy chamber somewhat below the water surface.

The length of the cylinder is equal to the water depth plus the tidal range plus 10-15 feet that is above the surface. At its top are daymarks and an appropriate light.

Articulated lights mark positions where more precision is needed than buoys can give, and in water too deep for a pile or dolphin structure. Since they do not have chains, they are almost always directly over their sinkers. They have very small watch circles.

CHART SYMBOLS

Chart symbols help you identify individual ATONs. The symbol for a buoy, for example, is a diamond with a small watch circle at its tip. If the buoy is lighted, the watch circle is overprinted with a larger, magenta colored disk. Magenta is used because it is visible under the red lights used in many cockpits and on ships' bridges at night.

When the diamond symbol is green, it represents a green buoy. When red, it represents a red buoy. Letters and figures printed next to the diamond tell us more about the buoy. For example, in the notation ***G "9" Fl G 4s***, the "G" means green and "9" is the number on the buoy. The buoy has a light that flashes green every four seconds. The italics tell us that it's a buoy and not a fixed mark. This buoy appears at the left of Plate 1.

Suppose a preferred channel buoy has a green top band and that its green light flashes in a composite group every six seconds. On a chart it would appear as a buoy symbol with the top half green and the bottom half red. It would have a magenta disk overprinted on the watch circle and the notation ***Fl (2 + 1) G 6s*** such as that for buoy "C" of Plate 1.

Fixed Structure Lights

Lights on fixed structures, including minor lights, also have their individual chart symbols. These are magenta colored exclamation marks with black dots. The dots on the symbols show the locations of the structures. In addition, each light's period, color, number, height, and the distance from which it may be seen appear on the chart. If the position is only an approximation, it is marked PA. The chart symbol and description shown in figure 5-18 indicate a fixed minor light that flashes green every six seconds. It is 12 feet above mean high water, and it can be seen for three miles in clear weather.

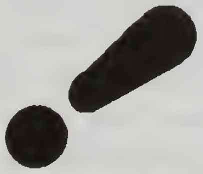


Fig. 5-18. Chart Symbols and Descriptions for Lighted Structures

Symbols for Buoys

The chart symbol for a can buoy is a green diamond with a small watch circle. If the buoy is not overprinted in magenta, you know that it has no light. The green color indicates a can. If the description printed next to the diamond were ***G C "7"***, you would know that it is green can number 7. Red nun buoys have symbols that follow a similar pattern. Plate 1 shows a complete description of a green can ("7") and a red nun ("6").

Symbols for Daymarks and Minor Lights

A green daymark appears on a chart as a green square. If the description on the chart were **G "1"**, you would know that it is daymark number 1. The symbol for a red daymark is a red triangle. Plate 1 shows the symbols for daymarks.

The symbol for a minor light differs from that of a daymark. It has a magenta exclamation mark (also called a "teardrop") to tell you it is lighted and a black dot to tell you its location. The chart will also provide a description of the light, which will be similar to that in figure 5-18. The upper left portion of Plate 1 shows the symbol and description of minor light "1."

You can also tell from a chart if an ATON is a buoy or a fixed structure by the type in which its description is printed. The symbols and descriptions of fixed ATONs are printed in "straight-up" Roman type. The symbols and descriptions of floating structures and buoys are printed in *italics*. You can find additional chart symbols on Plate 3.

LIGHT STRUCTURES

Lighted aids to navigation may be as small as minor lights on wooden piles in small creeks or they may be as large as tall lighthouses on the coasts. Their intensities also vary from weak to brilliant. They may be small, battery-powered minor lights or they may be powerful lights with millions of candlepower such as those in coastal lighthouses. Regardless of their sizes or intensities, they serve the same functions as buoys and daybeacons. Except for lighthouses, they have the same numbering, coloring, light, and sound characteristics as buoys.

Lighthouses

Lighthouses are Short Range Aids (SRA). They are not a part of any buoyage system. They are built where they will give the most help. Their primary purpose is to mark prominent headlands, harbor entrances, isolated danger areas, and other points. They also serve to support a light at a considerable height above the water. Some have quarters for personnel.

Lighthouse structures vary considerably in appearance. Their designs depend upon their needed heights, their locations, and the geological structures that support them. The *Light List*, a publication that lists all aids to navigation, gives a brief description of each lighthouse. The description given for Alligator Reef Light (fig. 5-19) in the Florida Keys is typical. It says, "White octagonal pyramid skeleton tower enclosing stair cylinder and square dwelling; black pile foundation."

Cylindrical or conical towers may have distinctive color combinations painted on them. The Cape Hatteras light in North Carolina has black and white spirals. The structure and its distinctive colors make up a lighthouse "daymark" to help navigators identify them during the day. Their lights usually shine only at night.

The distance a lighthouse must be seen is a major consideration in its height and location and the intensity of its light. The higher and the more brilliant the light, the farther away it is visible.

Lighthouse Sectors

Some lighthouses have "**RED**" **SECTORS**. This means that their normally white lights appear red when viewed from within those sectors. This is done by placing red glass in the beams of light from the lighthouses. Red sectors are shown on charts of the area. They mean danger. Viewed from where there is shallow water, rocks, or other dangers, the lights appear red.

The red sectors of Alligator Reef light are shown in figure 5-19. The light is normally white, but to a person between the dotted lines it is red. The spaces between the dotted lines are the red sectors.

The "tear drop" magenta mark symbol for Alligator Reef Light tells you that it is a light.

This light flashes in groups of four flashes each 40 seconds. The light is 136 feet above mean high water and can be seen for eight miles on a clear night. From its height you can tell it is a major light. Thus, you expect its light to be white, which it is except in its red sectors. Charts often include pictures of major lights to aid in identifying them.

Classes of Light Structures

Lights on fixed structures are classified. They include *primary* seacoast lights, *secondary* lights, *river* or *harbor* lights, and *minor* lights. The *Light List* describes each light. These descriptions include:

a. name and light rhythm,
b. location (latitude and longitude),
c. nominal range (distance the light can be seen under optimal conditions),
d. height above the water,
e. type and appearance of the structure including height above ground and daymark, if any,
f. characteristics of sound devices present, and
g. the year built.

Light Structure Sound Signals

Most lighthouses and major lights and some minor light structures have fog horns or other sound-producing devices. These warn mariners of danger in periods of poor visibility. On some floating structures, the signals operate either mechanically or electrically. Electrical operation is more dependable than mechanical, which may depend on wave action.

You can identify a particular structure by the timing of its signals, the silent period between signals, and the tone of the signal. These

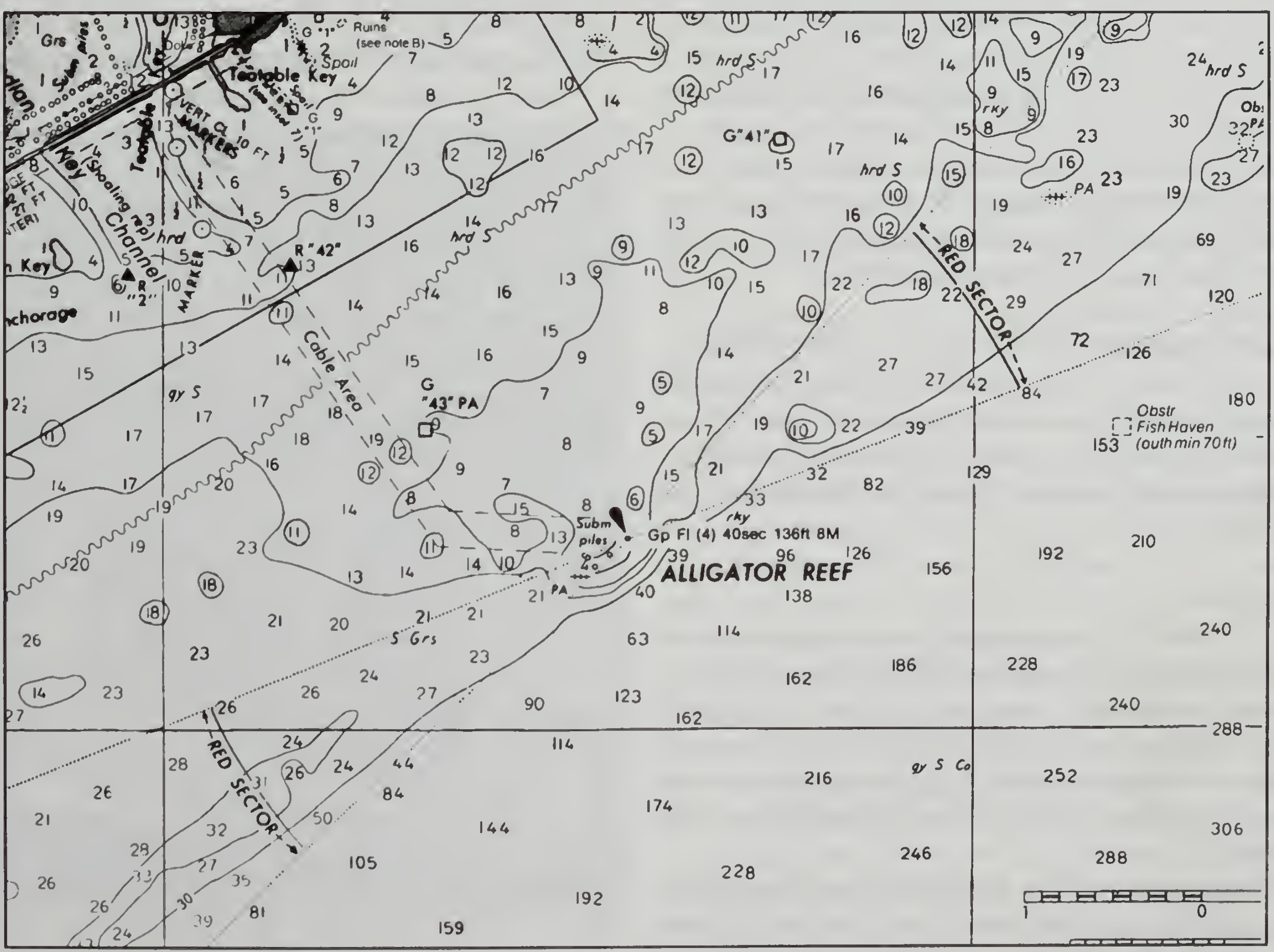


Fig. 5-19. The Red Sectors of Alligator Reef Light

are given on nautical charts. When the number of blasts and the time for a complete cycle are not enough to identify the structure, you may refer to the *Light List*. The exact length of each blast and silent interval is described.

In some boating areas there may be several active fog horns. Each has its own period and tone. When you boat in such an area, you need to be able to recognize each to help assure safe passage.

LIGHTS ON BRIDGES

Nautical charts show bridges and describe them and their characteristics. Bridges are described as "fixed" or "draw." Also listed are their horizontal and vertical clearances when closed. A **BASCULE** bridge is a type of drawbridge.

The lights on bridges do not conform to any buoyage system. Red lights mark piers and other parts of bridges. Red lights also show you that a drawbridge is in the closed position. A green light marks the navigable channel through a fixed bridge while red lights mark each side of the channel. Green lights also show that a drawbridge is in the open position.

Sometimes there is more than one safe channel under a bridge. In this case, the preferred channel has three white lights in a vertical line above its green light.

ELECTRONIC AIDS TO NAVIGATION

An array of sophisticated electronic navigational aids is available to assist you. These include **LORAN-C, SATELLITE NAVIGATION SYSTEMS, RADAR, RADIO DIRECTION FINDERS,** and others.

Loran-C

Loran-C is a commonly used electronic aid to navigation. Its receiver is coupled to a small microprocessor (computer) which measures time delays in signals from loran transmitters. A loran transmitting chain consists of a master station plus two to four secondary stations.

Signals from the secondary stations follow those from the master at very precisely timed intervals. The difference in time between when you receive a master station's signal and a secondary station's signal establishes a line of position. By measuring time delays from two or more secondary stations and consulting your chart, you can determine your vessel's approximate position.

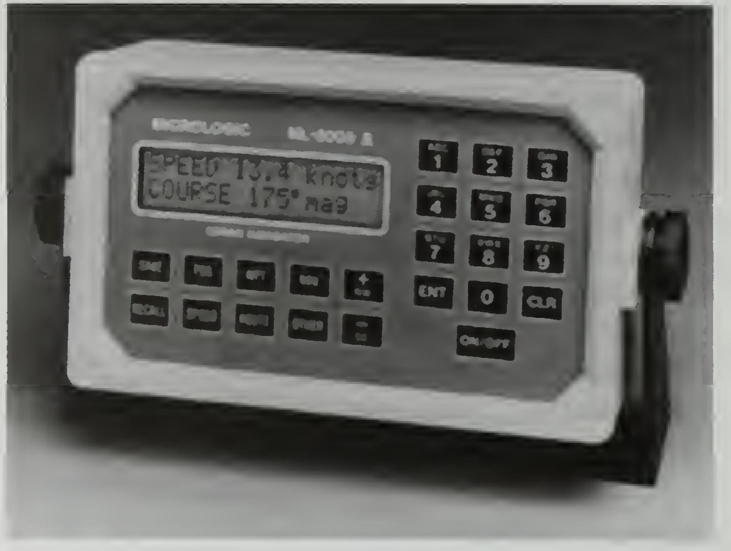


Fig. 5-20. Loran-C Receiver
(Photo courtesy of Micrologic Inc.)

The accuracy of the position determined by loran varies with the relative positions of the secondary stations and your vessel. In some areas, positions are accurate within 100 to 200 feet. Loran receivers and their computers can give a vessel's position both in time delays (which can be interpreted on charts) and latitude and longitude. They can also give the distance to another position, the direction of the second position, and the estimated time of arrival if the current speed of the vessel is maintained.

Satellite Navigation

The U.S. Navy developed the Satellite Navigation System (SatNav). It consists of five or six satellites in polar orbits. These send signals on two frequencies, one of which is used on non-military sets. The satellites are roughly 580 miles above the earth and circle it every 107 minutes.

When a satellite rises above the horizon, you can make a "fix" and determine your vessel's position. Since the spacing of the satellites is not uniform, the average time between fixes varies from 30 to 95 minutes. The farther away from the poles you get, the longer it takes to get a fix with the system.

Originally, SatNav receivers were very expensive. More recently, costs have been considerably reduced. SatNav is being replaced by a more accurate system called the **GLOBAL POSITIONING SYSTEM (GPS)**, sometimes called NavStar.

The Global Positioning System

The Global Positioning System (GPS) is rapidly increasing in popularity. It has 26 working satellites and additional "standby" satellites in orbits 10,900 miles above the earth. As with SatNav, these satellites emit two different signals. The military signals give highly accurate information.

The civilian signals are "degraded" and are accurate only within about 100 meters. As the cost of NavStar receivers decreases, there will probably be an increase in its use. At the same time, there will probably be a decrease in the use of loran-C.

As with any electronic system of navigation, sole reliance should not be placed in GPS. Likewise, when you use it, be certain that your chart uses the same horizontal datum as your GPS receiver. Otherwise, differences in positioning will result.

Fig. 5-21. Global Positioning System Unit (Photo courtesy of Shakespeare)

The Coast Guard Global Positioning System Information Center (GPSIC), located at the Coast Guard OMEGA Navigation System Center in Alexandria, Virginia, was created to make GPS advisory information available to civil and non-Department of Defense users. It also responds to general radionavigation system inquiries.

Coast Guard *Local Notice to Mariners*, published by each Coast Guard District, carries notices to inform users of forecasts of long range outages. VHF-FM Coast Guard Maritime Information Broadcasts regarding the system are given, as needed, on channels 16/22A.

GPS brochures and publications are available upon request from:

Commanding Officer
OMEGA NAVSYSCEN/GPSIC
7323 Telegraph Road
Alexandria VA 22310-3998.

Radio Direction Finders

Radio direction finders are of two types: radio direction finders (RDF) and **AUTOMATIC RADIO DIRECTION FINDERS (ADF).** Each can use either of two radio frequency bands, a low frequency band or the AM broadcast band. The low frequency band uses radiobeacons operated by the Coast Guard. The broadcast band uses commercial stations.

To use a radio direction finder it is necessary to have a chart showing the locations and frequencies of broadcast station transmitters and radio beacons. You can plot the directions of two or more of these transmitters on a chart and determine your vessel's position. You are where the direction lines cross.

RDFs and ADFs can "home in" on signals. That is you can steer your vessel toward the transmitter. As with ranges, you must exercise care in how far to follow the radio beam. Most broadcast transmitters are on land.

At one time there were more than 200 RDF stations. These are being phased out because of systems such as Loran-C and GPS. Coast Guard plans call for only 50 operational radiobeacons by the year 2000.

Radio Navigation User Information

Additional radio navigation information is available from two menu-driven bulletin boards that can be accessed by computer users with modems. There are no charges for these services. The first of these two menu-driven bulletin boards is maintained by the Coast Guard and can be accessed at 703-313-5910. The modem parameters are: 8 bits, 1 stop. A public bulletin board, operated by the National Oceanographic and Atmospheric Administration, with parameters of 8 bits, no parity, 1 stop is also available from Boulder, Colorado at 303-497-5000. Both of these bulletin boards transmit at 300-2400 bytes per second.

Voice recorded information about GPS is available from the Coast Guard at 703-313-5907. It can also be contacted at any hour at 703-313-5900 for general radio navigation information or for printed materials on GPS.

Loran-C operational status information is available from the Coordinators of Chain Operations (COCOs). Besides recorded information, the COCOs respond to queries. Some of the regional COCOs are:

- Canadian East Coast, St. Anthony, New Foundland, recorded announcement 709-454-3261; COCO 709-454-2392,
- Great Lakes and Northeast United States, Seneca, NY, recorded announcement 607-869-5395; COCO 607-869-1334,
- Southeast and South Central United States, Malone, FL, recorded announcement 904-569-5227; COCO 334-899-5225/6, and
- Canadian West Coast, Gulf of Alaska, West Coast and North Central United States, Alameda, CA, recorded announcement 510-437-3232.

GPS information is also available from the broadcasts of short wave radio stations WWV, Fort Collins, Colorado at 14 to 15 minutes after each hour, and WWVH, Kekaha, Hawaii at 43 to 44 minutes after each hour.

A WORD TO THE WISE

All electronic navigation systems are unreliable at times. Transmitting stations go "off line." Battery failure makes equipment inoperable. And instruments fail. Prudent mariners do not rely solely on electronic navigation systems. Instead, they know dead reckoning and coastal piloting and use these as their primary navigational tools.

You will be introduced to dead reckoning and coastal piloting in chapter 7, Piloting Your Boat. You can learn more about these subjects and electronic navigation systems in our Advanced Coastal Navigation course. Ask your instructor when the next class will be held.

NAVIGATION PUBLICATIONS

There are a number of publications to aid you. Chief among these are charts of your boating areas. Since the location, characteristics, and maintenance status of ATONs change from time to time, obsolete charts can be dangerous. Be sure yours is current.

There are several sources of charts. Most of them rely on charts produced by the National Oceanic and Atmospheric Administration (NOAA). You can get charts at marinas, boat stores, and other chart dealers.

Each district of the Coast Guard publishes a weekly *Local Notice to Mariners*. Copies are available from your district office of the Coast Guard. Addresses of the district offices are in Appendix B of this book. Use the information in the Local Notice to keep your charts and light lists up-to-date. This publication also includes other important information such as bridge conditions, proposed military operations, and special marine events.

Chart No. 1, Nautical Chart Symbols, Abbreviations, and Terms is useful in interpreting nautical charts. NOAA and the Defense Mapping Agency publish it jointly. You can get one through commercial sources.

The *Light List* helps you to identify aids to navigation. The Coast Guard publishes it. It is available in several volumes:

Volume I, Atlantic Coast, describes ATONs in United States waters from the St. Croix River in Maine to Ocean City Inlet in Maryland.

Volume II, Atlantic Coast, describes ATONs from Ocean City to Little River in South Carolina.

Volume III, Atlantic and Gulf Coast, describes ATONs in U.S. waters from Little River to Econfina River, Florida and the Greater Antilles.

Volume IV, Gulf Coast, describes ATONs from Econfina River to the Rio Grande in Texas.

Volume V, Mississippi River System, describes ATONs on the Mississippi and Ohio rivers and navigable tributaries.

Volume VI, Pacific Coast and Pacific Islands, describes the ATONs in United States waters on the Pacific coast and Pacific islands. For the convenience of mariners, it includes some of the lighted aids on the British Columbia coast.

Volume VII, Great Lakes, describes ATONs maintained by the Coast Guard and some of the aids maintained by Canada on the Great Lakes and the St. Lawrence river above the St. Regis river.

Light Lists are available to you for a fee from the Superintendent of Documents, Government Printing Office, Washington DC 20402. They are also available from branch offices of the GPO, located in many cities, and from sales agents in most major ports. The *Notice to Mariners* publishes a list of sales agents annually. The list also appears in a pamphlet available free of charge from the National Ocean Service, Distribution Branch (N/CG33), 6501 Lafayette Ave., Riverdale MD 20737-1199.

Do You Enjoy Teaching?

Auxiliary Public Education courses offer you the opportunity to teach boating safety.

Do you like to talk with boat owners? As a vessel examiner you will help them determine that their vessels comply with Federal, State and Auxiliary requirements.

Do you like to help people on the water who need assistance? You can provide this help when you become a Boat-Crew qualified Auxiliarist.

Do you enjoy the fellowship of other boaters? There are lots of opportunities in the Auxiliary for socializing.

Contact your instructor for information on how to join the U.S. Coast Guard Auxiliary

6

The Rules You Must Follow

The danger of collisions has existed since the second vessel was built. **NAVIGATION RULES** exist to help prevent such mishaps. Navigation Rules are to vessels what "rules of the road" are to automobiles.

TWO SETS OF RULES

There are two sets of rules--**INTERNATIONAL** and **INLAND**. Together, they are the Navigation Rules. Two sets are necessary in this country since our rivers, bays, and other inland waters have some dangers that require special rules for safe navigation.

The Navigation Rules apply to all vessels on the **NAVIGABLE WATERS** of the United States. These waters are those which provide a means of transportation between two or more states or to the sea. They also include the territorial waters of the United States. The International Rules also apply to all U.S. vessels on the high seas when they are not subject to another nation's jurisdiction.

The International Rules

Rules to prevent collisions have been evolving for the past 150 years. We now use the 1972 International Regulations for Preventing Collisions at Sea. Other names for them are the International Rules and the **72 COLREGS**.

The Inland Rules

The Inland Navigational Rules Act of 1980 became effective in 1981. Before that time, vessels on inland waters followed several sets of rules. These included an older set of Inland Rules, the Western Rivers Rules, the Great Lakes Rules, and parts of the Motorboat Act of 1940. If you think it is confusing to operate under two sets of rules as we do today, think of what it was like before 1981.

Both sets of rules appear in *Navigation Rules, International--Inland* published by the U.S. Government Printing Office. You can get a copy from the Superintendent of Documents

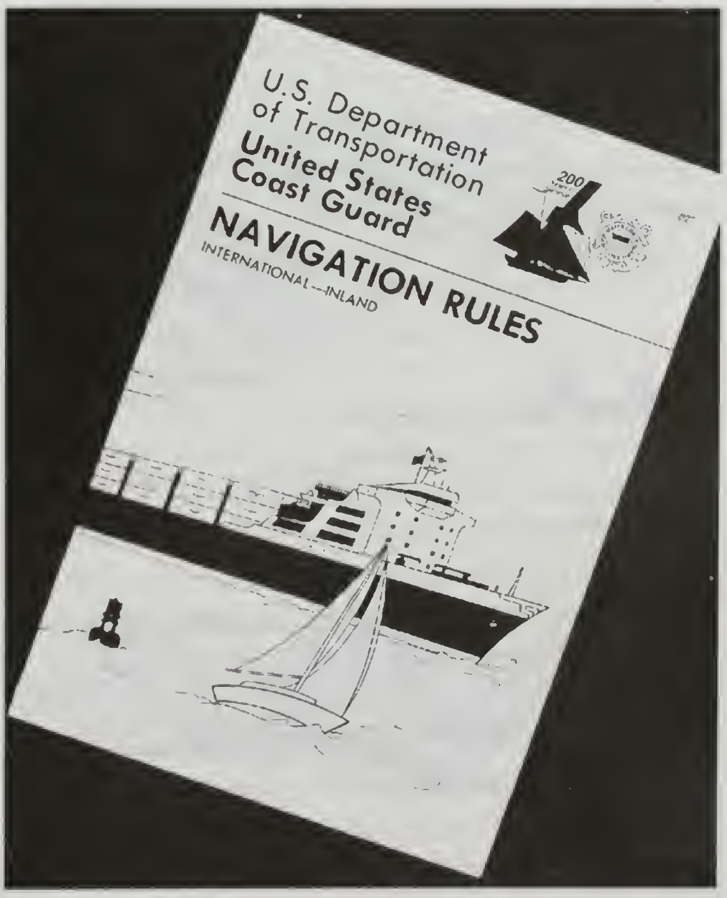


Fig. 6-1. The Navigation Rules

or at most marine supply stores. Any boat 12 or more meters long, must have a copy aboard. The penalty for failure to do so can be as much as $5,000.

Your Local Waters

The Inland or International Rules may not regulate boating on your local lake or other local water. Instead, local ordinances or state laws may cover them. If not, when you boat on them, use the same rules of common sense that underlie the Inland and the International Rules.

Demarcation Lines

DEMARCATION LINES separate waters on which the Inland Rules apply from those regulated by the International Rules. The Commandant of the U.S. Coast Guard draws these lines. You can see them on some navigational charts.

In general, the demarcation lines follow the coasts. Across bays and other inlets, they go from one easily described point of land or landmark to another. Seaward of these lines, the International Rules apply. Landward, the Inland Rules apply. Exact descriptions of the demarcation lines appear in the *Navigation Rules*.

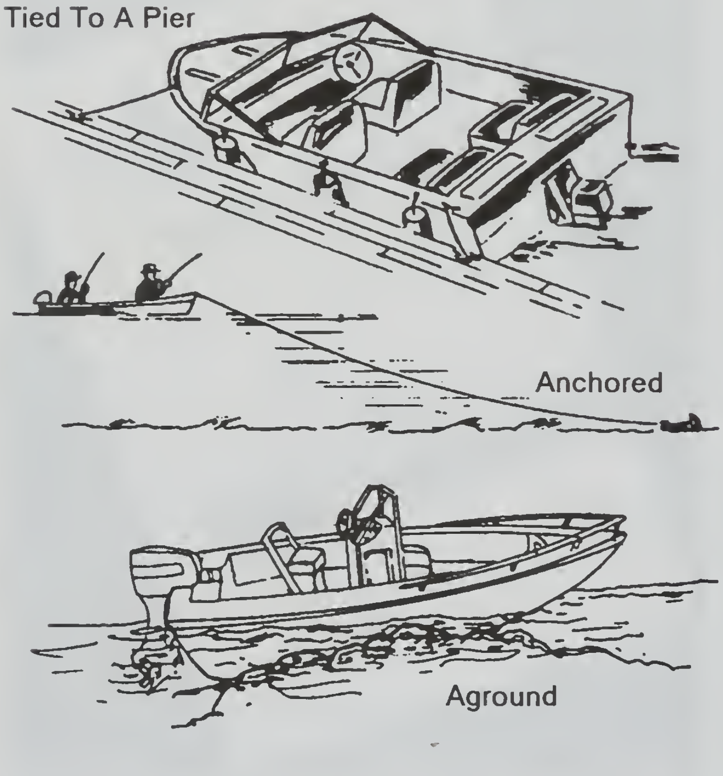


Fig. 6-2. Vessels Not Underway

TO WHOM DO THE RULES APPLY?

Rule 1 of each set tells you to whom the rules apply. The International Rules "...apply to all vessels upon the high seas." In addition, they apply on all connecting waters such as rivers and bays that are navigable by seagoing vessels. The Inland Rules "...apply to all vessels on the inland waters of the United States." They apply also to U.S. vessels on the Canadian waters of the Great Lakes unless they conflict with Canadian law.

WHAT IS A VESSEL?

Rule 3 tells us what a vessel is. "Vessels" are every type of watercraft, including **SEAPLANES**, which can be used for transportation on water. Seaplanes are "...aircraft designed to maneuver on the water."

The rule further defines **POWER-DRIVEN VESSELS** as vessels propelled by machinery. **SAILING VESSELS** are vessels under sail, not using propelling machinery. If they use power or sails and power, they are legally classed as power-driven vessels.

Vessel Underway

Some of the rules require an understanding of the term **"UNDERWAY."** An underway vessel is not at anchor, nor made fast to a shore or pier, nor aground. A vessel **MAKING WAY**, is being propelled through the water. It is adrift when it is not being propelled, not at anchor, not made fast to the shore, nor aground. A drifting vessel is underway but **"NOT MAKING WAY."**

Fishing Vessel

A **FISHING VESSEL** is any vessel fishing with nets, lines, trawls, or other fishing apparatus that restricts its ability to maneuver under the rules. Vessels fishing with trolling lines are not "fishing vessels." Your vessel is not a "*fishing*" vessel if you are sport fishing.

Vessel Restricted in Ability to Maneuver

Some vessels are **RESTRICTED IN** their **ABILITY TO MANEUVER.** This means that their work keeps them from abiding by the rules and staying out of the way of other vessels. Dredges, cable and pipe laying vessels, and other such vessels are "restricted in their ability to maneuver."

Vessel Not Under Command

A vessel is **NOT UNDER COMMAND** if some *exceptional* circumstance keeps it from **MANEUVERING** as required by the rules. This means that it can't keep out of the way of other vessels. A drifting boat with an inoperative engine or steering system is "not under command."

Vessel Constrained by Draft

The International Rules describe a **VESSEL CONSTRAINED BY DRAFT**. This is a power-driven vessel, severely restricted in its ability to change course because of its draft and the depth of the water. The Inland Rules do not contain such a definition.

THE GENERAL RESPONSIBILITY RULE

Rule 2 is the general responsibility rule. It has two principal aspects.

The "Rule of Good Seamanship"

Part (a) of the general responsibility rule has been called the "Rule of Good Seamanship." It says that nothing in the rules excuses you from failing to follow the rules. It also says that nothing in the rules excuses you from failure to practice good seamanship. In situations not covered by the rules, you must take the action required by their special circumstances.

The "General Prudential Rule"

Part (b) of the general responsibility rule is sometimes called the "General Prudential Rule." It says when you apply the rules, consider all the dangers to navigation. Also, consider any special circumstances that may make you depart from the rules to avoid immediate danger. "Immediate danger" means that you do not abandon the rules just because you perceive a risk of collision. Do so only when it is imperative that you act to avoid a collision. You *must* depart from the rules, however, to avoid an imminent collision.

Assessing Legal Liability

There are important differences in legal liability between maritime and civil law. Because each skipper *must* act to prevent a collision and *must* depart from the Navigation Rules when necessary, all parties usually share some responsibility for a marine accident. This does not mean that the shares are equal. That is a matter for a court to decide.

If you violate the rules and have a collision, you are at least partially responsible no matter what the other skipper does. The same is true for skippers under the influence of alcohol or drugs. In boating accidents, they are usually at least partially responsible no matter what the other skippers do. It is not unusual for all parties to be responsible for some act they did or did not do. Only rarely do marine accidents produce a finding of fault on only one skipper.

GENERAL CONSIDERATIONS

The rules make several important generalizations.

Vessel Size and the Rules

All vessels from the smallest personal watercraft to the largest supertanker must obey the rules. It would be foolhardy, though, for you to demand your "rights" under all circumstances. Large vessels are not as maneuverable as small ones. A supertanker, for example, may take several miles to stop even when operating astern propulsion. Large freighters throw up high wakes that can swamp or capsize small boats. Keep away from them.

Deep draft tugs can create dangerous currents, especially in shallow water. They can sweep small vessels into these currents with serious results. Keep clear of them.

When a tug is pushing a long line of barges, its operator has a blind spot immediately ahead of the barges. The longer the line of barges, the larger the blind spot. The operator can't see you if you pass in front of the barges. Even when you are seen, the operator can't do anything to avoid hitting you if you come too close. Avoid passing in front of barges and large vessels.

Maintain a Lookout

Both sets of rules require every vessel to maintain a proper **LOOKOUT**. The lookout must listen for danger as well as look for it. The lookout must also use all means available for watching. This includes radar, if available. Even if the rules did not require a lookout, common sense suggests such a need. ***The principal cause of vessel collisions is failure to maintain a lookout!***

Lookouts should have nothing else to do. Don't divide their attention. If you are alone on a vessel and it is underway, you must serve as your own lookout. Otherwise, appoint someone as lookout. This person should not be responsible for anything else. Change lookouts frequently.

Fig. 6-3. Always Maintain a Lookout

Safe Speed

The rules require all vessels to proceed at safe speeds so they can stop or take proper and effective action to avoid collisions.

The rules do not say what a safe speed is. They do say that a safe speed depends on visibility, traffic density, maneuverability of your vessel, sea state, current, wind, and other factors. If you were to have a collision, you probably would be judged to have been travelling at an unsafe speed. This can happen even if you were maintaining a proper lookout.

In **RESTRICTED VISIBILITY**, you must slow down. Darkness, fog, mist, falling snow, sleet, heavy rainstorms, sandstorms, smoke, and other conditions restrict visibility.

Do You Have Radar?

Even if your vessel is fitted with radar and it is operational, you must maintain a lookout and travel at a safe speed. A radar set may actually increase your responsibility. You must use it whenever it can help you avoid a collision. With it, you may be able to detect another vessel before it sees you. Thus, you may be the first to see that a collision is possible and that evasive action is necessary.

You must assess radar information carefully. Do not make hasty conclusions. Consider your radar's efficiency and limitations. Carefully evaluate the effects on it of sea state, weather, and other interference. Remember that your radar may not be able to detect small vessels or floating objects. Also, evaluate the number, location, and movement of vessels shown by your radar. You have responsibility for your radar's proper use and interpretation. Using radar does not relieve you of the responsibility to mount a lookout.

CONDUCT IN NARROW CHANNELS

Both sets of rules require all vessels in a narrow channel or fairway to "keep to the right." Don't impede the passage of a vessel that can navigate safely only within the channel or fairway.

Don't cross a narrow channel or fairway when it will impede a vessel that can travel safely only in the channel or fairway. You must not anchor in a narrow channel, except in an emergency.

The Inland Rules have an additional requirement for narrow channels with currents. Vessels travelling with the current (downbound) in narrow channels or fairways have the right-of-way. (This is the only place in the rules where the term right-of-way appears.) This rule is in effect on the Great Lakes, Western Rivers, and other specified waters. The upbound vessel must yield and allow the downbound vessel to pass. The rule exists because it is easier to control your vessel when you are going against the current than when you are going with it.

TRAFFIC SEPARATION SCHEMES

The *International Rules* make provision for traffic separation schemes (TSS) and they regulate traffic in them. A TSS is a system of one-way lanes used in congested traffic areas.

Normally, vessels join or leave a TSS at its end. If you enter otherwise, do so at a small angle. You should not cross traffic lanes but if you must cross, do so as nearly at right angles to the traffic flow as you can. Don't anchor in a TSS unless you have an emergency.

VESSEL TRAFFIC SERVICES

The Coast Guard maintains **VESSEL TRAFFIC SERVICES (VTS)** in New York, New Orleans, Houston-Galveston, San Francisco, Valdez, and Puget Sound and its approaches. VTSs are also on St. Mary's River in Michigan, Berwick Bay in Louisiana, and the Ohio River at Louisville, Kentucky. Canada operates VTSs on the St. Lawrence River and in Vancouver, B.C.

When you are boating in waters where there is a VTS, learn its location and whether it uses TSS lanes. If so, you must be able to recognize the buoys that mark the lanes. Never travel the "wrong way" or anchor in a lane.

STAND-ON OR GIVE-WAY?

To interpret the rules, you must understand the terms **STAND-ON** and **GIVE-WAY**. The Navigation Rules require that a stand-on vessel maintain its course and speed unless a danger of collision is imminent. A give-way vessel must take whatever action is necessary to avoid a collision. A stand-on vessel maintains course and speed so that a give-way vessel can predict what the stand-on vessel will do.

It is also important for you to know that no vessel has the "right-of-way." Instead, when vessels meet, one is usually stand-on while the other is give-way. The fact that no vessel has the right-of-way explains, in part, the sharing of liability in marine collisions. When driving, one automobile often has the legal right-of-way over another. This is not so for watercraft.

The Danger Zone

Determination of who is stand-on or give-way requires an understanding of how vessels are sectored.

As you probably know, there are 360 degrees in a circle. On a vessel, *three* sectors account for the 360 degrees. As you can see from figure 6-4, one sector is from **DEAD AHEAD** to 22.5° **ABAFT**, or behind, the vessel's starboard beam. A second sector is from dead ahead to 22.5° abaft its port beam. Each of these two sectors is 90° + 22.5° or 112.5°. These two sectors account for 2 x 112.5° or 225°. This leaves 360° - 225° or 135° for your third or stern sector.

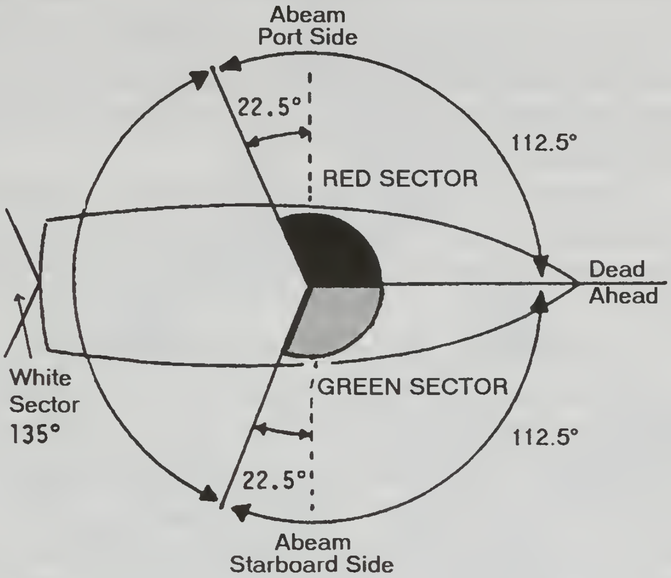


Fig. 6-4. Red, Green, and White Sectors of a Vessel

At night, the three sectors are easy to see if a boat's lights are correct. The sector on the starboard side from dead ahead to 22.5° abaft the starboard beam has a *green* light. It is called the green sector. It is the **DANGER ZONE**. The sector on the port side has a *red* light. It is the red sector. These red and green lights are the **SIDELIGHTS**. The danger zone has a green sidelight so other vessels seeing it know they are stand-on. (They have the green light.)

Most boats have white **STERNLIGHTS** with arcs of 135°. These shine astern. They also have white **MASTHEAD** lights that shine forward. Masthead lights have arcs of 225°. They cover the same sectors as sidelights. Together, masthead lights and sternlights cover 360°. Some small boats have all-round (360°) "masthead" lights instead of 225° masthead lights and separate sternlights.

Who Is Stand-On?

There are three situations in which the risk of collision exists. First, when you see both the red and green lights of another vessel dead ahead, you know you are on a collision course, meeting **HEAD-ON**. When the vessels are power-driven, both are give-way and each must alter its course to starboard.

Second, when you see another vessel's sternlight, you are **OVERTAKING** it. You are the give-way vessel and must avoid the other vessel.

Third, when your power-driven vessel approaches another vessel and you see its red light, you know you are the give-way vessel. The other vessel sees your green light and is stand-on. Alter your course to pass astern of the other vessel. This is a **CROSSING** situation. Never speed up to pass in front of a stand-on vessel.

When the danger of collision exists, be cautious. The other skipper may not see your lights or know what they mean. Should the other vessel not treat you as stand-on and alter its course, you must give the danger signal and change your course to prevent a collision. The danger signal is at least five short and rapid blasts on your whistle. (See chapter 2 for a description of a boat's whistle.) The change in course is usually to your starboard. When the other vessel is forward of your port beam and you are not overtaking it, *do not turn to port*. When the other vessel is **ABEAM** or **ABAFT THE BEAM** on either side of your vessel, *do not turn toward it.*

In the Daytime

In the daytime, although you will not see lights on the other boat, the same three zones exist. The danger zone is still the "green light" zone. When your vessel is power-driven and another vessel approaches you in this zone, you are give-way. You are also give-way if you approach the stern sector of another vessel.

Courtesy and Common Sense

Remember, courtesy and common sense are as important as the rules. Don't use your boat to argue with another skipper. If the other skipper is rude, don't use it as an excuse for rudeness on your part. If the other skipper does not treat you as stand-on, sound the danger signal and yield. The other skipper may not know the Navigation Rules. You could win the argument and ruin your whole day.

Constant Bearing

If the direction to another vessel stays the same, or nearly so, as you get closer to it, you are on a **COLLISION COURSE.** When this happens, take evasive action. For example, slow down to permit the other vessel to pass in front of you. You can, instead, change your course.

When you act to avoid a collision, make your change in course or speed large enough that it is readily seen. The other vessel should be able to see your change either visually or on radar. A change in course should be at least 60°. Even this may not be enough when approaching a large vessel or a tow or when you are close to another vessel.

RULES FOR SPECIAL VESSELS

Some vessels are less maneuverable than others. Because of this, the Navigation Rules give them special stand-on status.

Overtaking and Overtaken Vessels

For recreational boaters, three special provisions deserve attention. First, an overtaken vessel is stand-on to all other vessels. A sailing vessel which is overtaking another vessel is

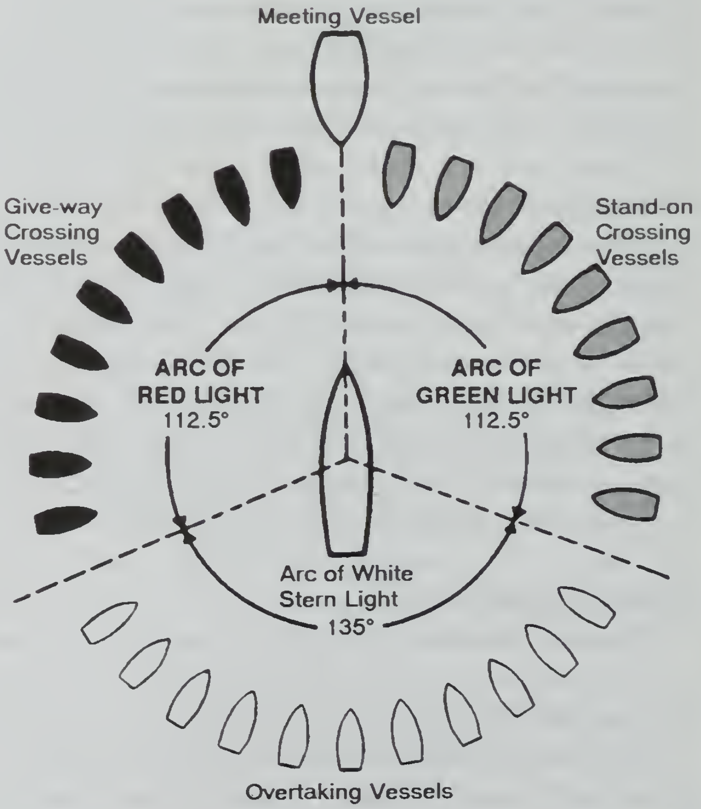

Meeting Vessel
Give-way Crossing Vessels
Stand-on Crossing Vessels
ARC OF RED LIGHT 112.5°
ARC OF GREEN LIGHT 112.5°
Arc of White Stern Light 135°
Overtaking Vessels

Fig. 6-5. The Three Situations

give-way to it even when the overtaken vessel is power-driven.

Second, except when it is being overtaken, a power-driven vessel is give-way to a sailing vessel. When a power-driven vessel meets a sailing vessel head-on, it is the give-way vessel. The same is true in a crossing situation—the power-driven vessel is give-way even if it sees the green sidelight of the sailing vessel.

Third, when on the water, sea planes are vessels. As such, they are give-way to all other vessels except when they are being overtaken.

Rules for Sailing Vessels

Because of their reduced maneuverability, both sets of Rules have special rules for sailboats in sight of each other. They are the same in both sets of Rules. They apply whenever there is a risk of sailboats colliding.

In overtaking situations, the overtaken vessel is stand-on.

In meeting and crossing situations the wind is the deciding factor. When each sailing vessel has the wind on a different side, the vessel which has the wind on its port side is give-way (see fig. 6-6). The vessel with the wind on its starboard side is stand-on.

The **WINDWARD** side of a vessel is the side toward which the wind is blowing. The leeward side is the side away from the wind. For example, when the wind is blowing toward the port side of a vessel, this is its windward side. Its starboard side will then be its leeward side.

When both sailing vessels have the wind on the same side, the vessel to windward is give-way (see fig. 6-7). So, the vessel which is upwind is give-way.

Sometimes you cannot tell if the wind is on the port or starboard side of another sailing vessel. If your sailing vessel has the wind on its port side and you cannot tell if a sailing vessel to windward has the wind on its port or starboard side, you must assume that it has the wind on its starboard side and is the stand-on vessel. You must keep out of the way of the other vessel.

For the purpose of the Rules, you can tell the windward side of a sailing vessel by noting the side on which the mainsail is carried. The windward side is deemed to be the opposite side.

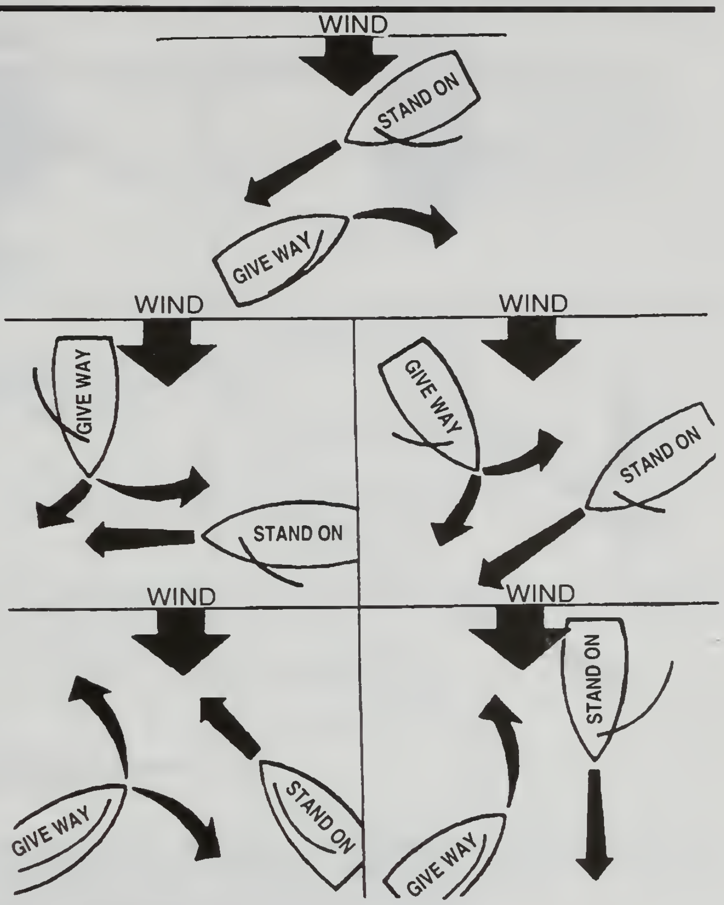


Fig. 6-6. International and Inland Rules for Sailing Vessels (Wind on Different Sides—Boat with Wind on Port Side Gives Way)

RISK OF COLLISION

A risk of collision can exist in head-on, crossing, or overtaking situations. The Navigation Rules prescribe the behavior of vessels in these situations and the signals power-driven vessels exchange.

Head-on Situations

Vessels that approach each other on reciprocal (opposite) or nearly reciprocal courses are meeting head-on. At night each vessel sees both the red and green sidelights of the other vessel. When you see both sidelights of another vessel, you should also see its masthead light or lights if it has them. When it is under sails and without power, a sailboat does not use a white masthead light.

When there are two masthead lights on a vessel and you are meeting head-on, they will be in a vertical line. The forward one will be lower than the aft one. Two masthead lights mean that the vessel is 50 or more meters long. Get out of its way!

A small vessel yaws in a heavy chop or in

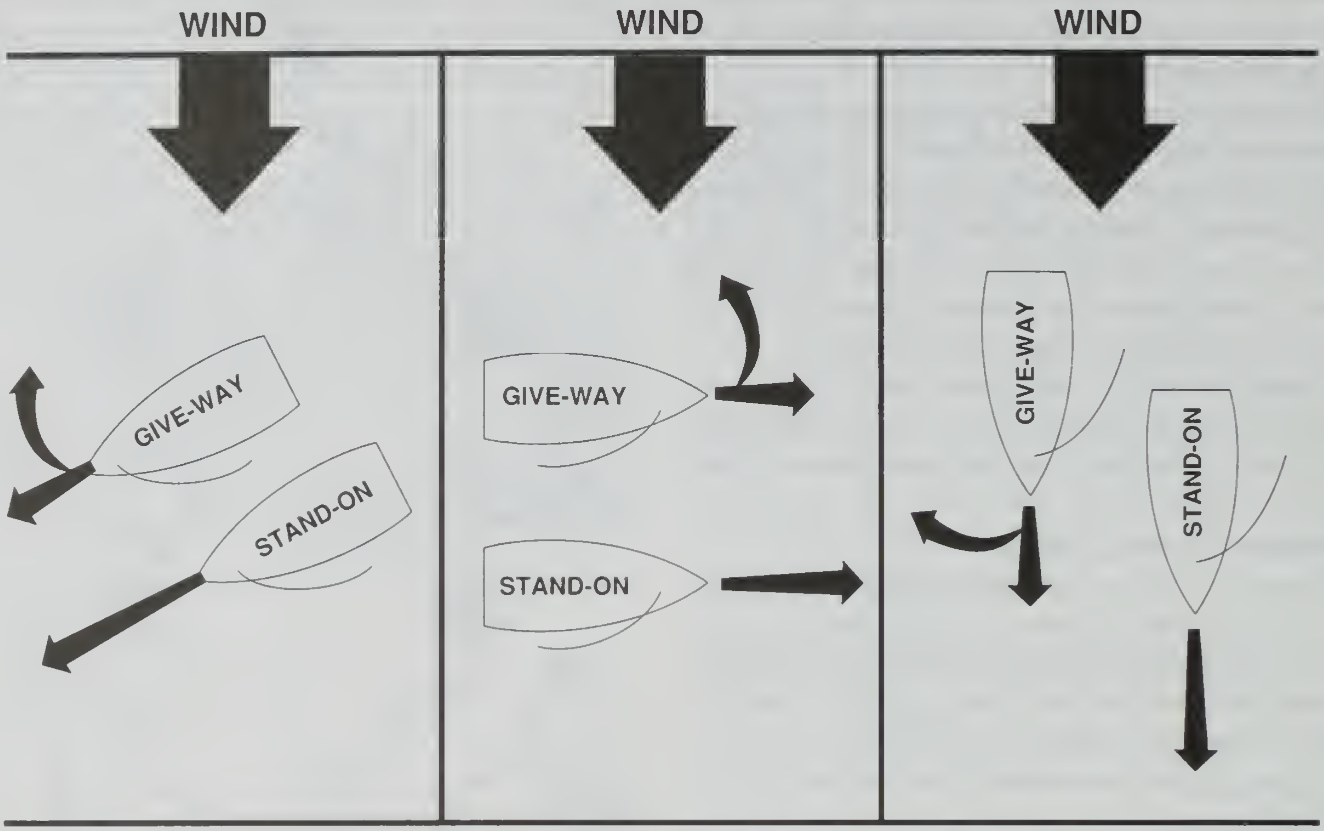


Fig. 6-7. International and Inland Rules for Sailing Vessels (When necessary to maneuver to avoid a collision, the upwind or the overtaking boat is give-way to the downwind or overtaken boat.)

ground swells. When this happens another vessel meeting it sees alternating red and green sidelights. When you see this pattern of sidelights, assume that you are meeting another vessel head-on.

It is not as easy to determine when a head-on situation exists in the daytime. If you have any doubt whether a head-on situation exists, assume that it does. In a head-on or meeting situation involving power-driven vessels, neither vessel is stand-on. Both are give-way.

"Head-on" Sound Signals

The usual course of action when two power-driven vessels are meeting head-on is for each vessel to alter its course to starboard. Sound signals are also given. In giving sound signals, a short blast of a whistle means a blast of one second's duration. A **PROLONGED BLAST** is a blast of four to six seconds. The term "long blast" is not used in the navigation rules.

International Meeting Signals

Under International Rules when power-driven vessels meet head-on or nearly so and a risk of collision exists, each vessel turns to starboard as in figure 6-8. At the same time, each gives one **SHORT BLAST** of its whistle. Thus, the vessels pass port to port. In head-on situations under International Rules, vessels do not alter course to port to pass starboard to starboard.

Whistle Signals

Whistle signals can be confusing to learn. To make it easier, think of yourself as a vessel's skipper. The word "port" has one syllable. You can associate one short blast with "port." The word "starboard" has two syllables. Associate two short blasts with it. Thus, in the head-on meeting situation described above, the other vessel will be on your port side as you pass it so you sound one short blast. Under Inland Rules, you may pass another vessel starboard to starboard. In this case, you sound two short blasts.

This "rule of thumb" is correct in most instances. As with most rules, there are exceptions. You should refer to the *Navigation Rules, International—Inland* for further guidance.

In a meeting situation under International or Inland Rules, when either vessel believes a collision is imminent it must take evasive action. This may consist of trying to stop. Three

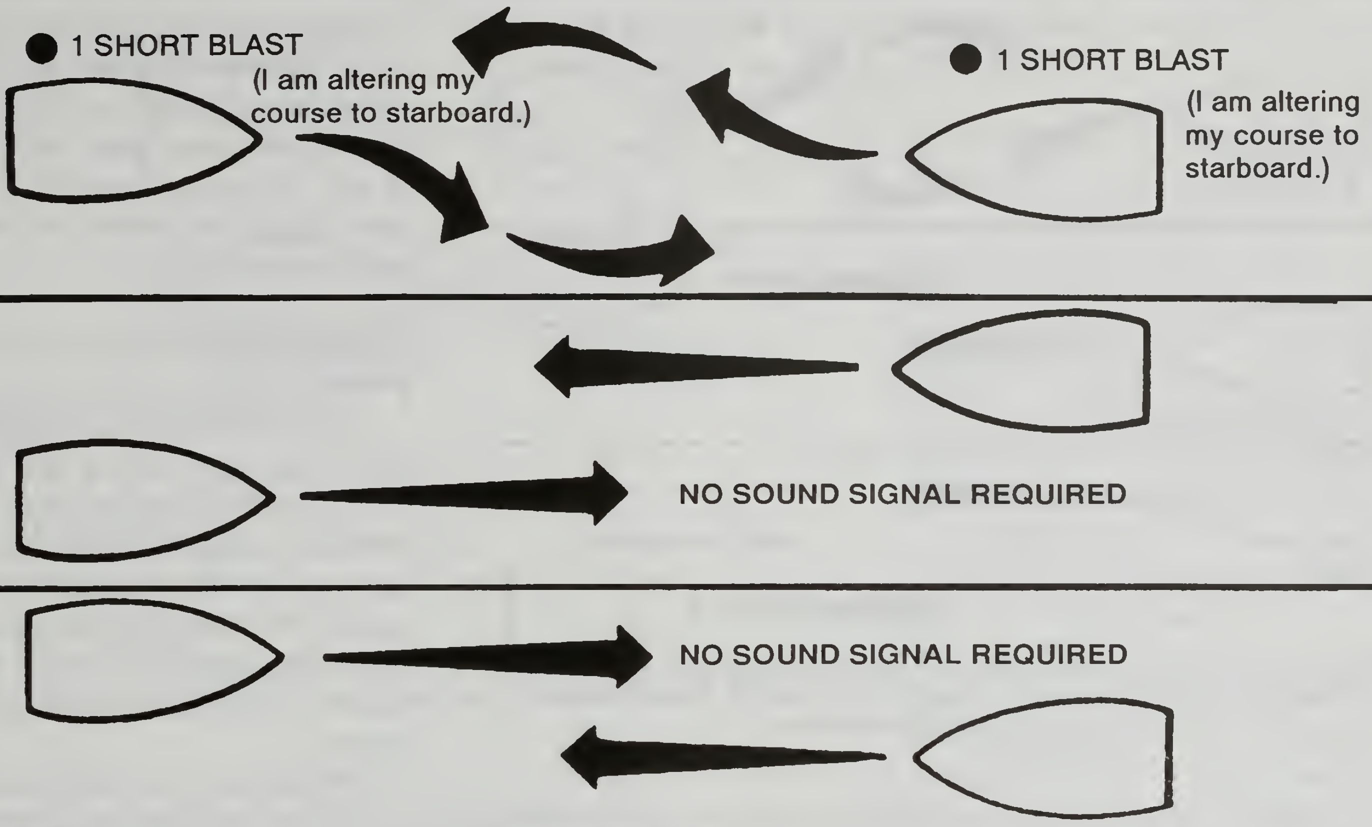

● 1 SHORT BLAST
(I am altering my course to starboard.)
● 1 SHORT BLAST
(I am altering my course to starboard.)
NO SOUND SIGNAL REQUIRED
NO SOUND SIGNAL REQUIRED

Fig. 6-8. Power-driven Vessels Meeting under International Rules. Neither Vessel is Stand-on.

short blasts signal such an action. They mean, "I am operating astern propulsion." This does not mean, "I am backing up." A heavy vessel can operate astern propulsion for some time before it overcomes its headway.

Inland Meeting Signals

Inland meeting signals for power-driven vessels are similar to those used in international waters but there are significant differences (fig. 6-9). One difference is that inland signals announce your *intention* to act. They also require a response before you can act. Except in overtaking situations in narrow channels and near obscured bends in a channel, International Rules do not require a response from the other vessel.

There is a second difference. In inland waters, when power-driven vessels in sight of each other meet head-on or cross within one-half mile, they exchange sound signals. They do this even if neither vessel has to change course.

In inland waters in a head-on situation, one short blast means, "I *intend* to pass you on my port side." Two short blasts mean, "I *intend* to pass you on my starboard side."

If the other vessel agrees to your intended maneuver, it signals its agreement by returning the same signal. If you sound one short blast and the other vessel agrees, it also sounds one short blast. Each vessel, if necessary, alters its course to starboard and the vessels pass port side to port side.

The other vessel answers a two blast signal with two short blasts. When necessary, each vessel then alters its course to port and the vessels pass starboard to starboard. When there is no danger of collision, neither vessel changes course.

If the second vessel disagrees or does not understand your intention, it should answer with the **DOUBT** or **DANGER SIGNAL**. This signal consists of at least five short and rapid blasts.

Cross Signals

Suppose, in inland waters you meet another power-driven vessel head-on and wish to pass port side to port side. You will sound one short blast. Suppose, however, that the other

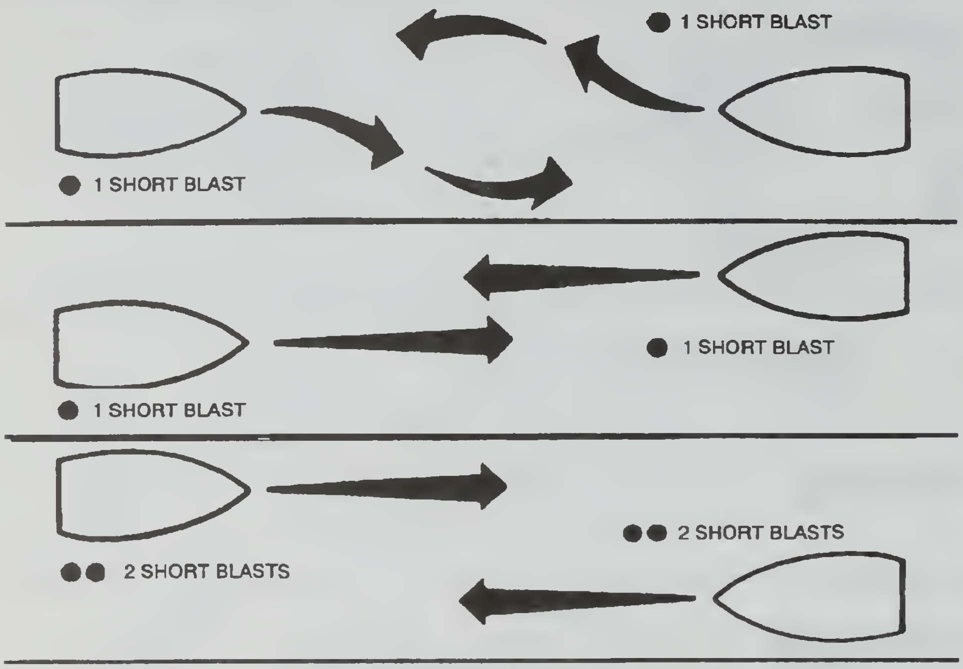


Fig. 6-9. Power-driven Vessels Meeting under Inland Rules. Neither Vessel is Stand-on.

vessel believes it would be better for your vessels to pass starboard to starboard. It cannot answer your one blast signal with two blasts. This is called CROSS SIGNALS.

Instead, the second vessel must respond with the doubt or danger signal. You can then sound two short blasts to announce your intention to pass starboard to starboard. When this is acceptable to the other vessel, it responds with two blasts. So, the other vessel must respond only with the signal you give or with the danger signal.

Crossing Situations

When two vessels meet and each sees either a red or a green light, they are crossing. One vessel is coming toward the other in an area from almost dead ahead to 22.5° abaft either beam. When you are not sure whether you are in a meeting or a crossing situation, assume you are meeting and take appropriate action.

When you are power-driven and see a green sidelight on another power-driven vessel, you are stand-on. The other vessel sees your red sidelight and it is give-way. When a crossing vessel is on your starboard side, you are give-way. You must stay out of its way. You can do this by slowing down and letting the other vessel pass in front of you. You can, instead, alter your course to starboard and pass astern of it.

Crossing in International Waters

In international waters, power-driven vessels do not have to give sound signals in crossing situations unless action is needed by the give-way vessel. Of course, either you or the other skipper can give the doubt or danger signal if necessary.

When the give-way vessel finds it necessary to alter course, it sounds one short blast to show it is altering its course to starboard (fig.6-10). It will then pass ASTERN of the stand-on vessel and the stand-on vessel will be on the give-way vessel's port side. The stand-on vessel does not respond.

Crossing in Inland Waters

In inland waters, the give-way power-driven vessel announces its intention to pass astern of the stand-on vessel by one short blast (fig. 6-

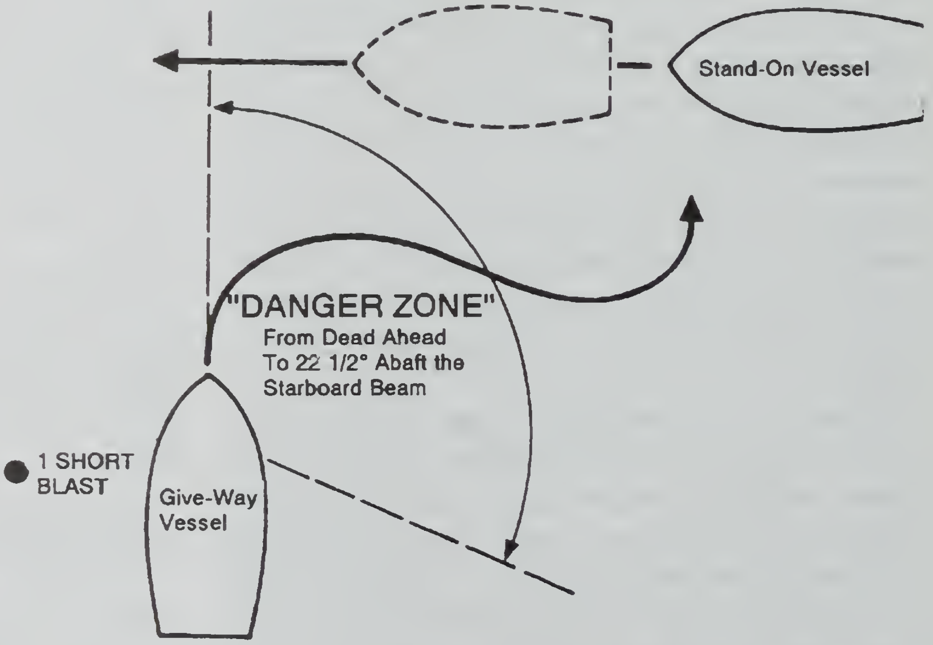


Fig. 6-10. Power-driven Vessels Crossing, International Rules

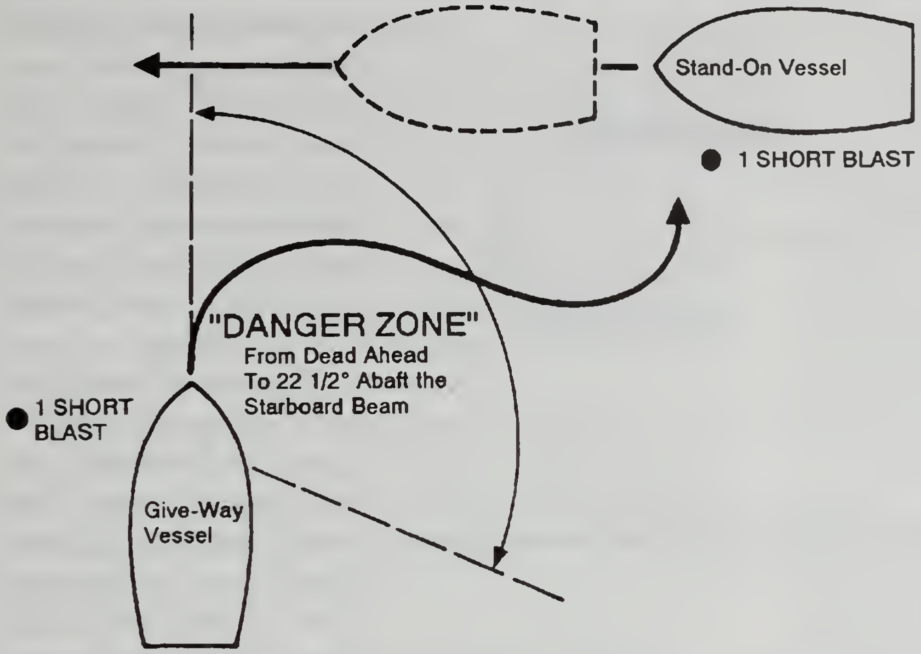


Fig. 6-11. Power-driven Vessels Crossing, Inland Rules

11). When this is agreeable to the stand-on vessel, it responds with the same signal, one short blast. Otherwise, it gives the danger signal.

Overtaking Situations

When you approach another vessel and see only its sternlight, you are overtaking it. This means you are approaching the other vessel from a direction more than 22.5° abaft either of its beams. When you are either power-driven or sailing, you are give-way and must stay clear of the overtaken vessel. If you can't tell if you are overtaking another vessel or crossing its path, assume that you are overtaking and that you are the give-way vessel.

Overtaking in Inland Waters

In inland waters when you intend to overtake a vessel, you announce your intention to pass it on your port side with one short blast. If this is acceptable to the other vessel, it responds with the same signal—one short blast. You then pass the overtaken vessel on your port side.

You state your intention to pass the overtaken vessel on your starboard side with two short blasts. Again, if agreeable to the vessel you are overtaking, it responds with the same signal—two short blasts. It can reject your intention by using the danger signal. Don't give cross signals.

Overtaking in International Waters

In open waters under International Rules if one vessel overtakes another from dead astern, the overtaking vessel must alter course. It sounds one short blast to show it is altering its course to starboard. If it alters its course to port, it sounds two short blasts.

Under either set of rules, you remain an overtaking vessel until you are finally past and clear of the overtaken vessel. Any change in bearing of the two vessels does not change your status. When you are an overtaking vessel, you cannot become a crossing vessel.

Overtaking in Narrow Channels

International Rules require sound signals when you are overtaking another vessel in a narrow channel or fairway. You must sound

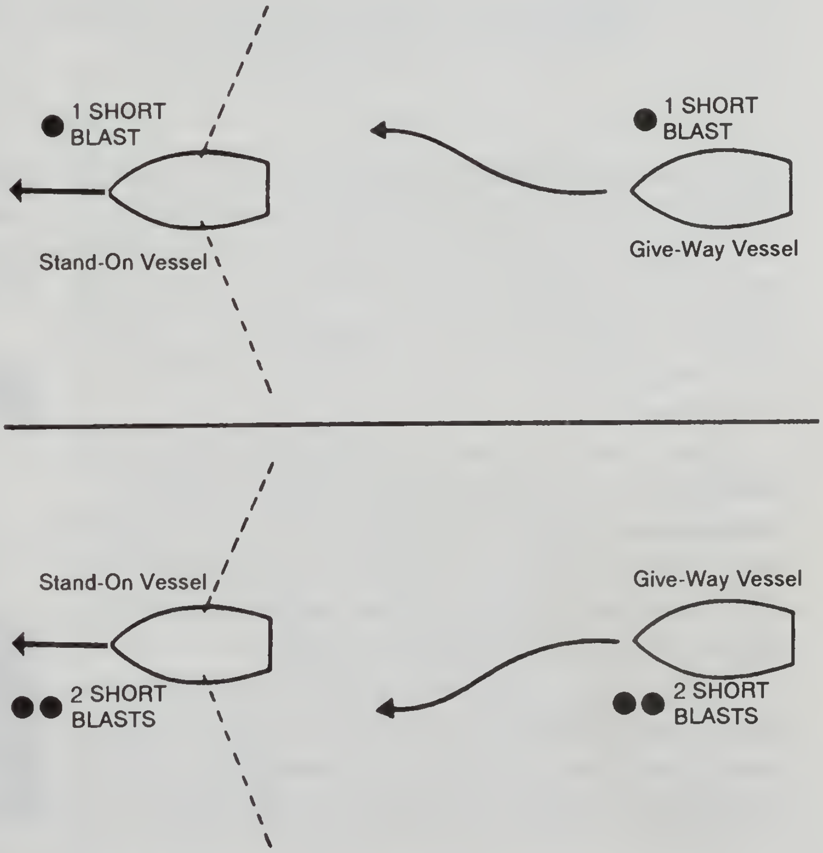


Fig. 6-12. Overtaking Situation, Inland Rules

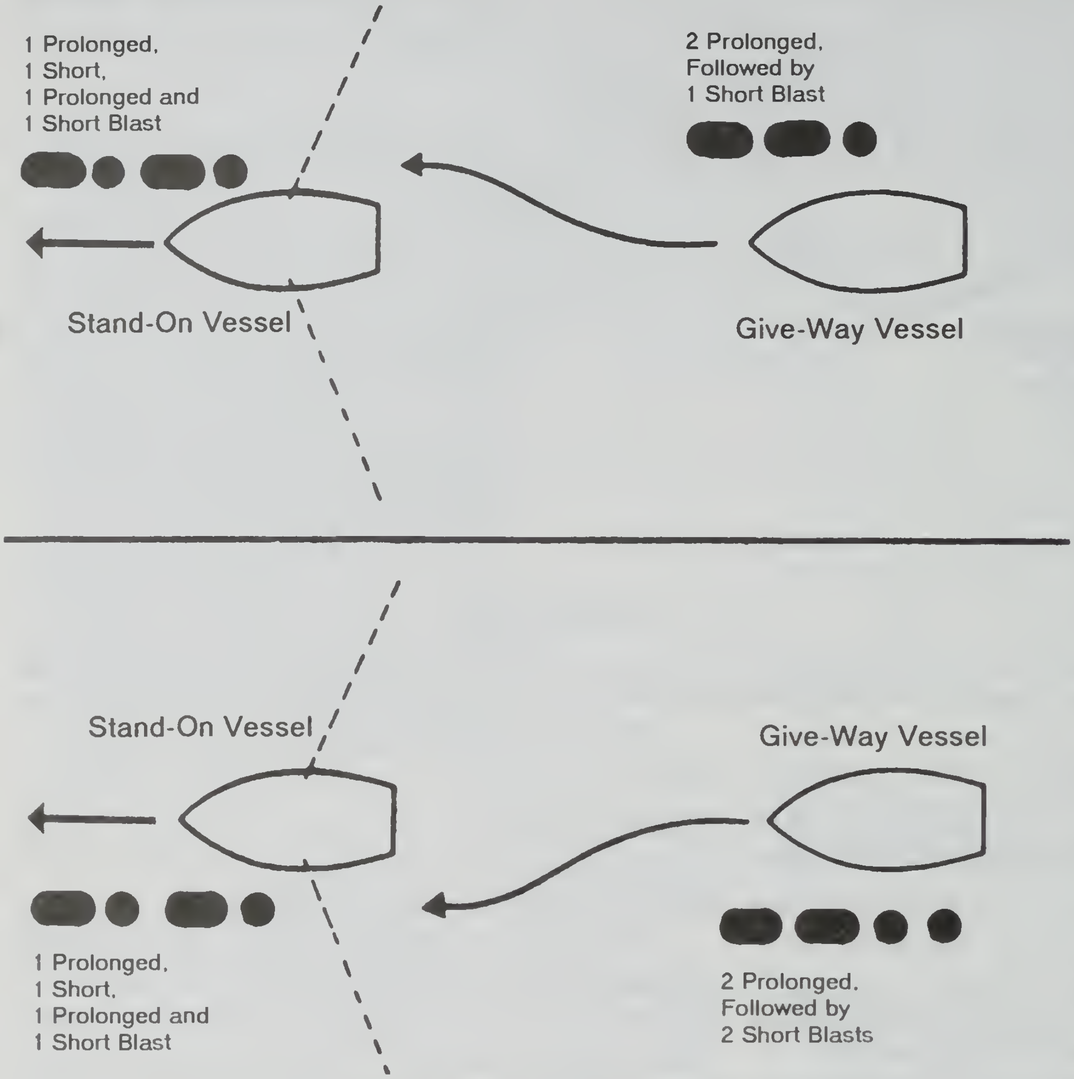


Fig. 6-13. Overtaking Situations in Narrow Channels, International Rule

two prolonged blasts and *one* short blast to say that you intend to pass the other vessel on your port side. When the other vessel agrees, it should sound one prolonged, one short, one prolonged, and one short blast. If it disagrees, it sounds the danger signal. You cannot pass until there is agreement.

Note that this situation is an exception to the general rule governing sound signals in international waters. In this case your signal announces intent, not action you are taking. It is also an exception in that it requires a response from the overtaken vessel.

When, in a narrow channel or fairway, you intend to pass the other vessel on your starboard side, sound two prolonged and *two* short blasts. If the overtaken vessel agrees, it responds with one prolonged, one short, one prolonged, and one short blast. It can, of course, respond with the danger signal. You can pass only after there is agreement. Don't give cross signals.

The one or two short blast rule still holds—when you overtake a vessel on your port side, sound one short blast. When you overtake on your starboard side, sound two short blasts. The difference in the rule, as applied here, is that you sound two prolonged blasts before either the one or two short blast signal.

BEND SIGNALS

In a narrow channel or nearing a bend you may have your view obscured. Both sets of rules require you to navigate with "alertness and caution." They also require you to sound one prolonged blast (fig. 6-14). An approaching vessel that hears your signal answers with a prolonged blast.

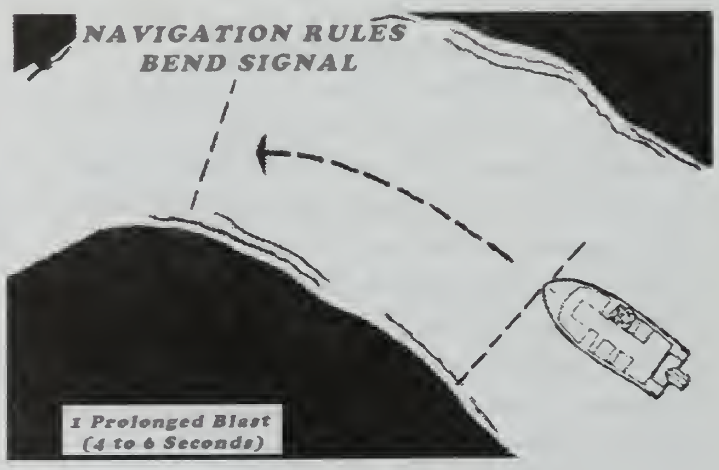


Fig. 6-14. Bend Signal, Power-driven Vessel

RESTRICTED VISIBILITY

Most of the rules relate to vessels in sight of each other. The rule for bend signals is an exception. So are the rules that regulate the conduct of vessels in or near an area of restricted visibility. In or near an area of restricted visibility, there is a different set of signals. ***In restricted visibility when vessels are not in sight of one another, no vessel is stand-on to any other vessel.***

Sound signals in restricted visibility are the same in both sets of rules. They may be hand-timed and mechanically produced or they may be automatically produced by electronic means.

Sound Signals Underway, Restricted Visibility

In or near an area of restricted visibility, use the following sound signals when underway:

- When you are power-driven and making way, sound one prolonged blast at least every two minutes.
- When you are power-driven and adrift, sound two prolonged blasts at least every two minutes. There should be an interval of about two seconds between your blasts.
- Some vessels underway sound one prolonged blast followed by two short blasts at least every two minutes. These include vessels not under command, those restricted in ability to maneuver, sailing vessels, vessels towing or pushing other vessels, and fishing vessels.

Sound Signals Not Underway, Restricted Visibility

When **NOT UNDERWAY**, give the following sound signals in restricted visibility:

- When you are at anchor in open water, ring your bell rapidly for about five seconds at least every minute. A vessel 100 meters or more in length, sounds a bell in its forepart. Immediately afterward, it sounds a gong for about five seconds in its after part. When you hear a bell and a gong, you know you are near a large vessel.
- At anchor you may also sound one short, one prolonged, and one short blast of your whistle. This tells an approaching vessel your position and warns of the chance of collision. When you are at anchor, you make more noise than when you are underway. You can afford to. When underway, you need to listen for sounds from other vessels.
- Should your vessel be aground, you must give the bell signal given by a vessel at anchor. In addition, you must give three separate and distinct strokes on your bell immediately before and after the rapid ringing of the bell.
- In a vessel less than 12 meters long, you do not have to give signals with a bell. If you don't, you must make some other efficient sound signal at least every two minutes.
- In *special anchorage areas,* vessels less than 20 meters long, do not need to give sound signals. Nautical charts show these areas.

In restricted visibility, if you hear a whistle or a horn, you know it is usually coming from a vessel underway. It may or may not be making way. A bell or a gong tells you the vessel is stationary, either anchored or aground.

VESSEL LIGHTS AND SHAPES

At night, your vessel must have proper **NAVIGATION LIGHTS**. You must show them from sunset to sunrise and in restricted visibility. When you show your navigation lights, don't show other lights that might appear to be navigation lights. Also, don't show other lights if they interfere with the vision of your lookout.

Except for searchlights, lights on boats serve different purposes than lights on automobiles. Boat lights do not help you see ahead. They are there to be seen, and to communicate certain information to other vessels.

Range of Visibility

The required intensities of your navigation lights are given in terms of their minimum required ranges of visibility. The required intensities of lights vary with their colors and purposes. See figure 6-15 for the intensities of lights required on your boat. If your vessel is less than 12 meters long, its lights should be visible as follows: masthead, two miles; sidelights, one mile; **ALL-ROUND LIGHTS**, two miles. (An all-round light shines in an arc of 360°.) Your boat manufacturer probably used properly sized bulbs. If you need to replace them, use comparable bulbs.

LIGHT TYPE	Visibility Min. Distance--Nautical Miles			
	1	2	3	5
MASTHEAD		●	▲	◆
SIDE	●	▲◆		
STERN		●▲◆		
ALL-ROUND		●▲◆		
TOWING		●▲◆		
SPECIAL FLASHING (Inland Rules Only)		●▲◆		

VESSEL LENGTH

- ● Less than 12 Meters
- ▲ 12 Meters but Less than 20 Meters
- ◆ 20 Meters but Less than 50 Meters

Fig. 6-15. Light Visibility Required

What Lights Tell You

You already know something about vessel lights. You know what sidelights, masthead lights, and sternlights are. You also know how to tell who is stand-on and who is give-way by looking at a vessel's lights.

The lights on another boat answer several questions for you. Is the other boat headed toward you? Is it crossing your course? Are you overtaking it?

LIGHT	ARC	ON DIAGRAM
MASTHEAD LIGHT	225°	A
SIDE LIGHT	112.5°	B
STERN LIGHT	135°	C
ALL-ROUND	360°	D

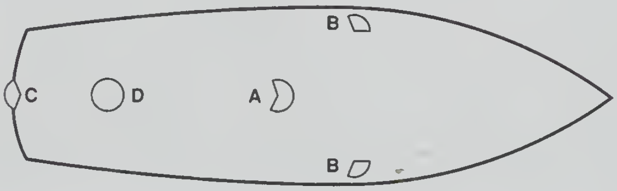


Fig. 6-16. Navigation Lights

The lights on vessels also help you to know something about their sizes. Larger vessels have more navigation lights than smaller ones. In general, the more navigation lights a vessel has, the greater the danger it poses for other vessels. Stay clear of vessels with navigation lights you do not understand and vessels with many navigation lights.

As you will see, the special navigation lights of a vessel often tell you something about its condition or activity.

"Shapes" on Vessels

In addition to lights, vessels show **SHAPES** to alert you to their special conditions or activities. Shapes are also called "day shapes" since they are the daytime equivalent of special navigation lights. One of the annexes (appendices) to the rules describes these shapes. All shapes are black. They may be **BALLS, CONES, DIAMONDS,** or **CYLINDERS.**

Lights and Shapes on Sailing Vessels Underway

At night, a sailing vessel underway must show sidelights and a sternlight as in figures 6-17 and 6-18. It does not have a lighted masthead light. Because of this, when a sailboat is correctly lighted and you see a sidelight but no white light, it is a sailing vessel underway. The lights on sailing vessels are the same under either set of rules.

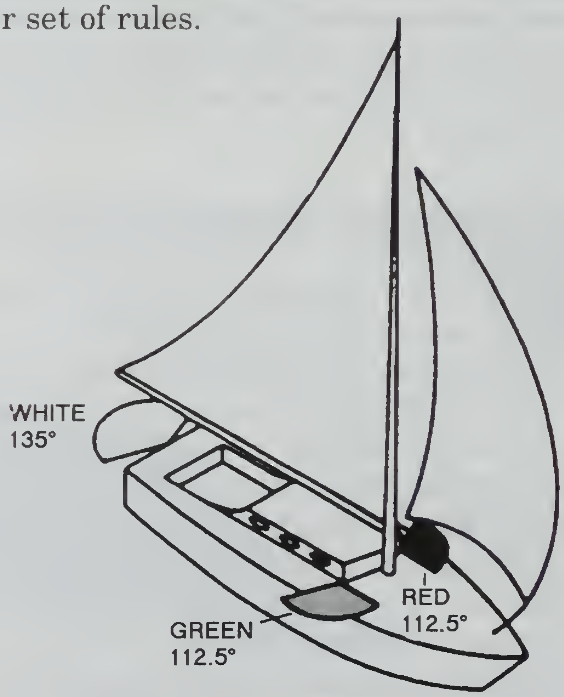


Fig. 6-17. Sailing Vessel Underway with Separate Sidelights, International and Inland Rules

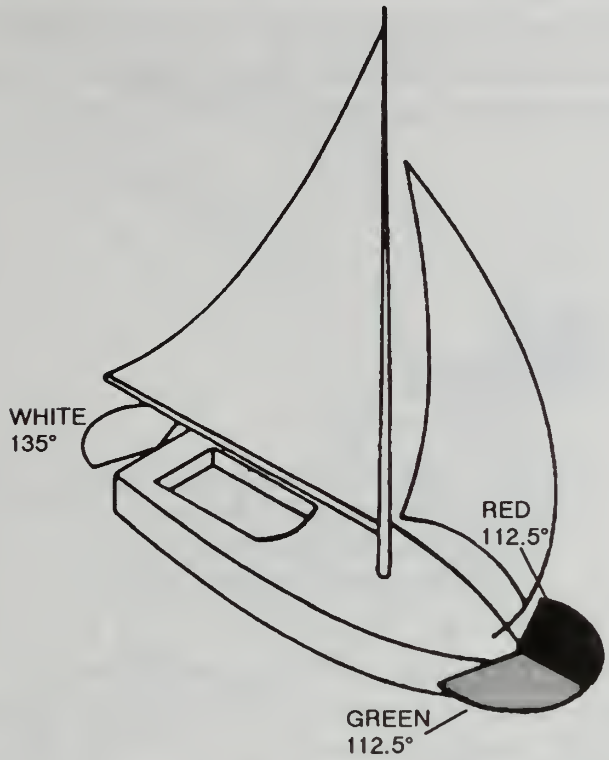


Fig. 6-18. Sailing Vessel Underway with Combined Sidelights, International and Inland Rules

The sidelights and sternlight of a sailing vessel less than 20 meters long may be combined in one device or fixture (see figure 6-19). This is carried at or near the top of a mast where it is most visible. Don't use this light on a sailboat under power. In that case, show the lights of a power-driven vessel (fig. 6-20).

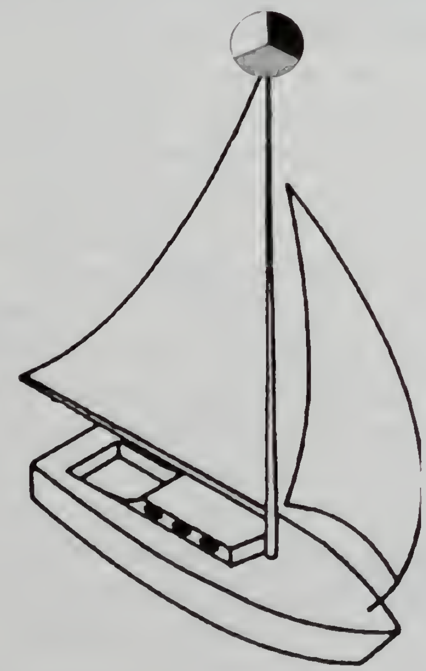


Fig. 6-19. Sailing Vessel Underway less than 20 meters in length, International and Inland Rules

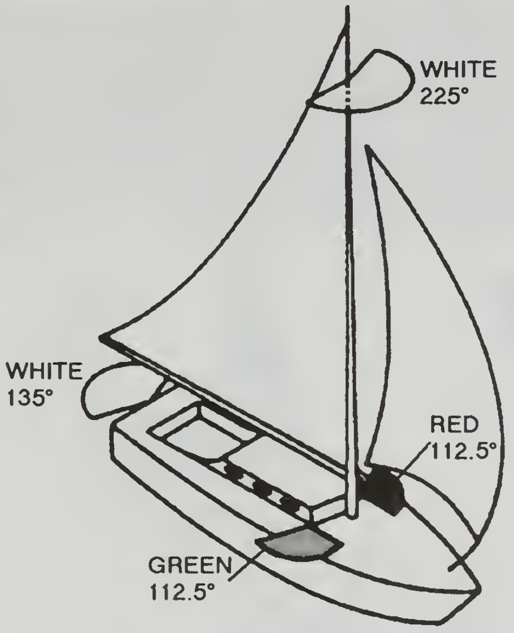


Fig. 6-20. Sailing Vessel under 20 Meters Using Both Sail and Power, International and Inland Rules

A sailing vessel underway *may* show, in addition to its sidelights and sternlight, two all-round lights in a vertical line as in figure 6-21. The upper light is red and the lower is green. These lights are at or near the top of its mast where they are most visible. These optional additional lights are not to be used with the three-color lantern, shown in figure 6-19.

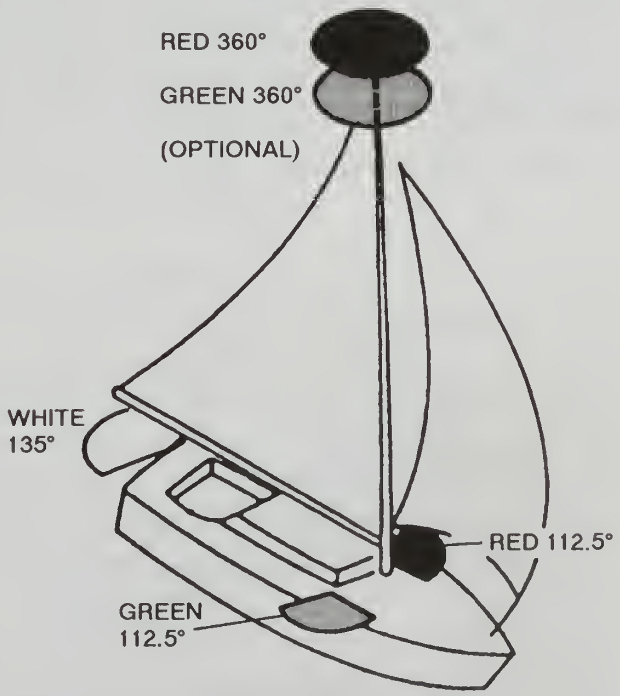


Fig. 6-21. Optional Sailboat Light Configuration, Inland and International Rules (Sidelights may be combined if desired.)

During daylight hours, a sailing vessel that is *also* under power must show a conical shape with its apex pointed downward. It shows this cone where it is most visible. Under Inland Rules, a sailing vessel less than 12 meters long need not display this day shape.

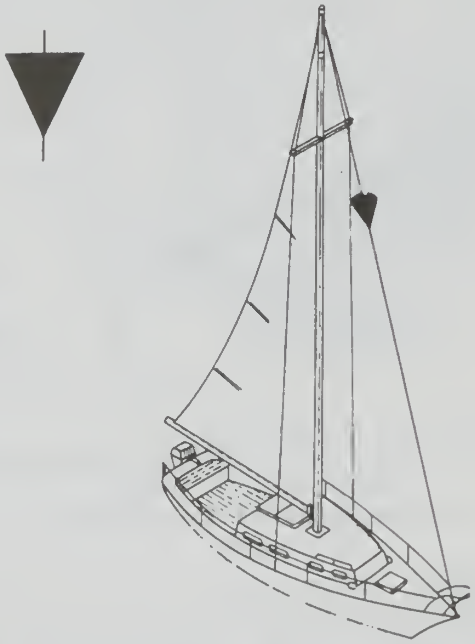


Fig. 6-22. Shape Used by Sailing Vessel under Power and Sail During Daylight Hours, International and Inland Rules

A sailing vessel less than seven meters long shall, if practicable, show the same lights as larger sailing vessels. If it doesn't have lights, it must have an electric torch (flashlight) or lighted lantern with a white light readily available. It must show this light in time to prevent a collision. Usually, the skipper directs the flashlight against the sail so it is easier to see.

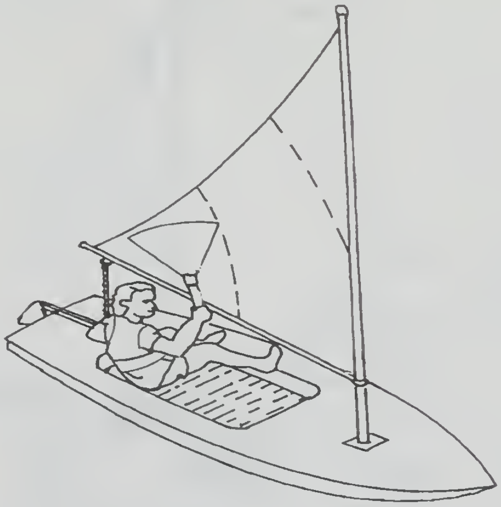


Fig 6-23. Light for Sailing Vessel Less than Seven Meters Long, International and Inland Rules

A rowboat may show the same lights as those used on sailboats. This includes the showing of a white flashlight or lantern.

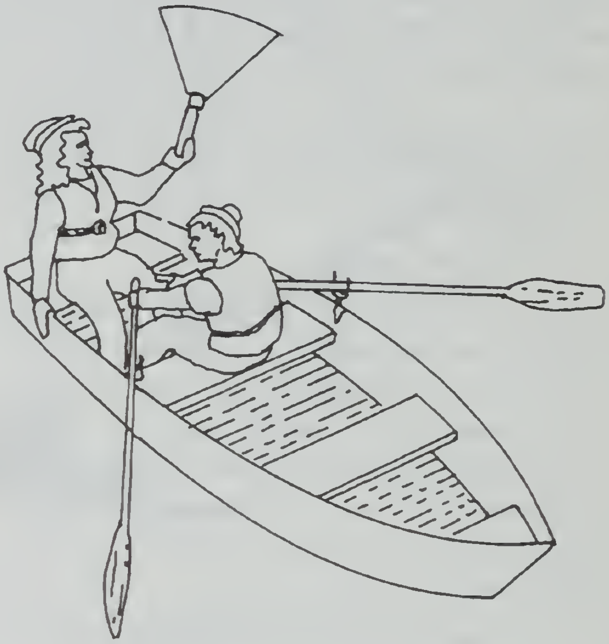


Fig. 6-24. Light on a Rowboat, International or Inland Rules

Lights for Power-Driven Vessels Underway

Navigation lights on power-driven vessels underway depend on the vessels' lengths and whether they are on international or inland waters. For small, recreational vessels, the two sets of rules are practically identical.

There are many rules regulating navigation lights on power-driven vessels. Only those which bear on recreational boating are described here. If you want to learn more about navigation lights, please see the Navigation Rules book cited earlier in this chapter.

Under either set of rules, a power-driven vessel less than 20 meters long must have sidelights, a masthead light, and a sternlight when underway at night. Its sidelights may be separate or combined in one lantern. The masthead light of a vessel 12 meters or more in length must be at least 2.5 meters above its gunwale. A power-driven vessel 50 meters or more in length, must have a second masthead light abaft and above the first one.

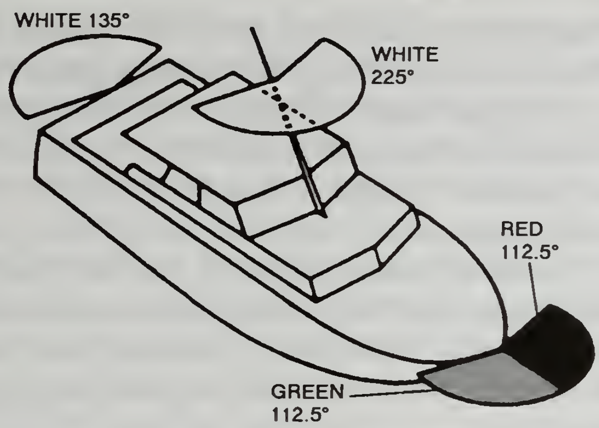


Fig. 6-25. Power-driven Vessel under 20 Meters Long, Inland and International Rules (Sidelights may be separate)

The masthead light of a vessel less than 12 meters long must be at least one meter above its sidelights. It may have an all-round light in place of the masthead light and sternlight. On either international or inland waters, if you see a white light and a sidelight on a vessel, the vessel is power-driven. At night, you should never see a white navigation light on a sailing vessel when you see a sidelight.

Many small vessels with all-round lights in place of masthead lights carry the lights too low. They must be at least one meter higher than the sidelights. The rules require that the lights "...be placed as to be above and clear of all other lights and obstructions." If the light on your vessel is not high enough, raise it.

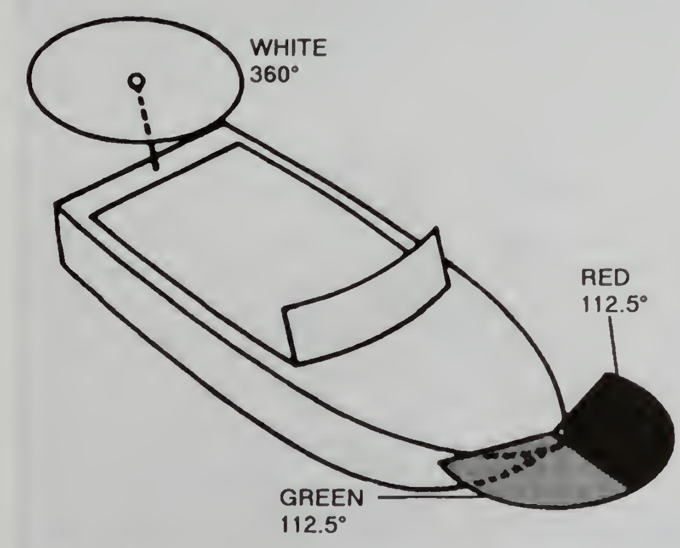


Fig. 6-26. Power-driven Vessel Under 12 Meters Long, Inland and International Rules (Sidelights may be separate)

In international waters, a power-driven vessel less than seven meters long needs only an all-round light if its maximum speed is not more than seven knots (eight miles per hour). Where practicable, it should also have sidelights.

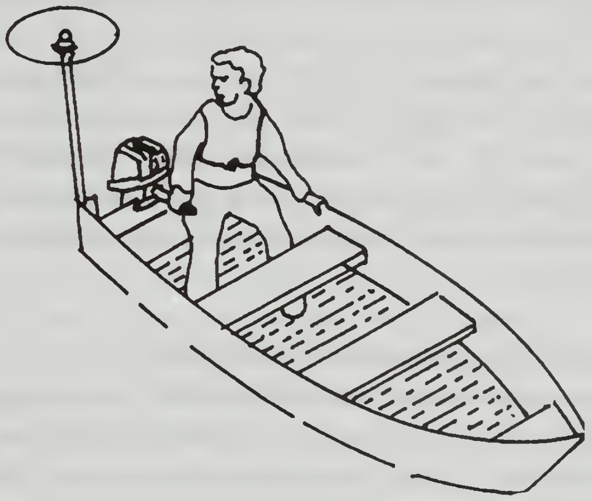


Fig. 6-27. Power-driven Vessel Less than Seven Meters Long, Underway in International Waters, Maximum Speed Does Not Exceed Seven Knots

Special Lights and Shapes

Special lights and shapes announce some activities or conditions of vessels. The lights are in addition to the masthead, stern, and sidelights required by the two sets of rules. Except for towing lights and lights on vessels constrained by draft, the lights are the same in the two sets of rules. The special shapes are the same in both sets of rules. Vessels show these special shapes in the daytime. At night, they show their special lights.

Fishing Vessels

A vessel trawling, that is, dragging a net or some other apparatus, shows two all-round lights in a vertical line. The upper one is green. The lower is white. In the daytime it shows a shape made of two cones in a vertical line with their apexes touching. A fishing vessel less than 20 meters long may, instead, show a basket.

A fishing vessel, other than one trawling, has two all-round lights in a vertical line. The upper one is red, the lower is white. It shows the same shape as a trawler. This type of fishing vessel may have long lines extending from it. If fishing gear extends more than 150 meters

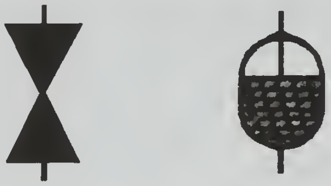


Fig. 6-28. Day Shapes Used By Fishing Vessels

from the vessel, it must have an additional all-round white light. This light is on the side with the gear. It also has a cone with its apex upwards on the side with the gear. This cone is in addition to the two cones whose apexes are touching.

Vessels Constrained by Draft

A vessel constrained by draft is recognized only in the International Rules. It shows its condition at night by three red all-round lights in a vertical row. In daylight hours, it displays a black cylinder.

Towing Vessels

A towing light is the same as a sternlight except it is yellow. A power-driven vessel, when towing astern, has two masthead lights in a vertical line, and the yellow towing light above its white sternlight. When the tow is more than 200 meters the vessel has three vertical masthead lights at night and a diamond shape in the daytime.

A sailing vessel could be confused with a vessel being towed at night. Like a sailboat, a boat under tow has a stern light and sidelights. Be careful. You may not be able to see the towing line.

Many boats have been destroyed and lives lost when skippers have steered between towboats and their tows. The towlines are not always visible. Be alert for two vessels moving in the same direction and staying the same distance apart. Watch for the yellow lights of the towboats at night or their diamond shapes in the daytime.

Other Special Vessels

Other vessels also have special lights. These include vessels restricted in their ability to maneuver, those not under command, those engaged in dredging (fig. 6-29) or underwater

Fig. 6-29. A Dredge Is Restricted in Ability to Maneuver.
(Courtesy of Corps of Engineers)

operations, and those aground. Remember, the more lights a vessel has, the larger it is and the more important it is for you to avoid it.

There are two kinds of vessels with special lights that you should recognize. Law enforcement vessels when engaged in law enforcement or public safety activities have flashing blue lights. These vessels include those operated by the Coast Guard, marine police, national and state park rangers, conservation officers, and others with police functions.

You should also know that a vessel engaged in public safety activities may have a flashing red and yellow light. The light serves only to identify the vessel as participating in such activities. It does not confer special privileges. Be aware that this vessel may be towing another vessel. Don't cut behind it.

VESSELS AT ANCHOR

A vessel less than 50 meters long will show an all-round white light at night in its fore part where it can best be seen when anchored. In the daytime, it will show a ball. When it is 50 meters long or longer, it will have an additional all-round white light near its stern. This light is lower than the forward light. All vessels may show lights to illuminate their decks. A vessel 100 meters or more in length, *must* show these lights.

Under either set of rules, an anchored vessel less than seven meters long does not have to show an anchor light or shape. However, when it is in or near a narrow channel, a fairway, an anchorage, or where other vessels normally navigate, it must show them at appropriate times.

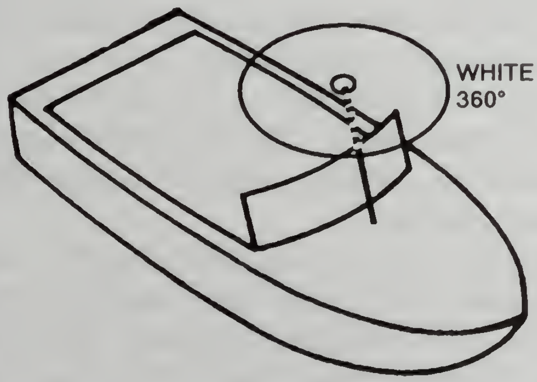


Fig. 6-30. Vessel Less than 50 Meters Long, at Anchor at Night

Under the Inland Rules, vessels less than 20 meters long do not need to show anchor lights or shapes when anchored in special anchoring areas. A list of these special anchorage areas appears in Title 33, Code of Federal Regulations, Part 110. They are also shown on nautical charts.

DIVING OPERATIONS

Vessels engaged in underwater operations should show the lights and shapes of vessels restricted in their ability to maneuver. They should do this under either set of rules.

A vessel has an alternative if its size makes it impracticable to show these lights and shapes. It can, instead, show three all-round lights. These are in a vertical line. The top and bottom lights are red. The middle light is white. It also flies a rigid replica of the code flag "A" to show a diver is down. This **ALFA FLAG** is a white and blue, swallow-tail flag. It must be at least one meter high and visible from any angle.

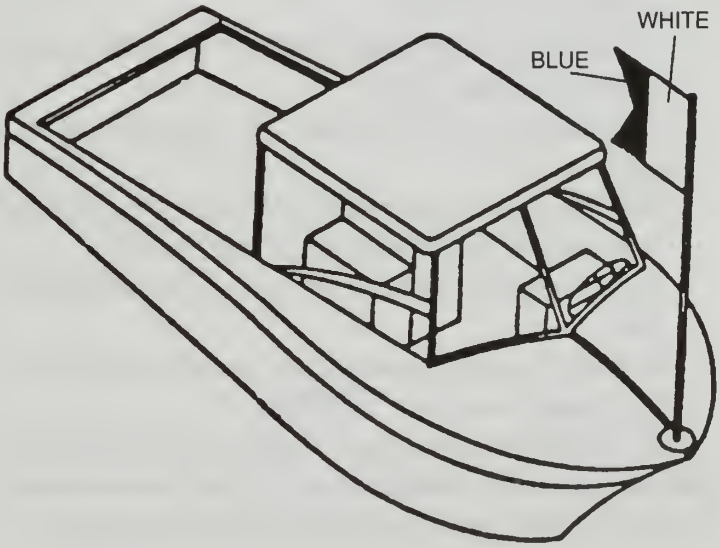


Fig. 6-31. Vessel Engaged in Diving Operations

The rules about the alfa flag cover "underwater operations." This has left scuba divers and snorkelers confused about the flag they should use. As a result, they have informally adopted a red flag with a white diagonal stripe (fig. 6-32).

This flag has legal status in some states. In most places, however, the flag does not have this status. To be on the safe side, some people use both the red and white and the alfa flags. If you see either of these flags, give them wide berth.

Do not paint or permanently affix a diving flag to your vessel. Use it only when there is a diver in the water.

DISTRESS SIGNALS

Distress signals are described in Rule 37 and in Annex IV. They include (see fig. 6-33):

- A gun fired at intervals of one minute,
- A continuous sounding of a fog horn,
- Red star shells,
- A Morse code SOS signal (• • • – – – • • •) sent by radiotelegraphy, flashing light, or other means,
- A radio signal consisting of the spoken word "MAYDAY,"
- Flying international code flags of "N" and "C" (November and Charlie in the phonetic alphabet),
- A black square and ball on an orange background.
- Flames on the vessel (as from burning tar or oil in a barrel),
- A rocket parachute flare or a hand flare showing a red light,
- A smoke signal giving off orange-colored smoke,
- Slowly and repeatedly raising and lowering your arms outstretched to each side,
- An automatic radiotelephone alarm signal, and
- Signals sent by emergency position-indicating radio beacons (EPIRBs).

In addition on inland waters, a high intensity white light flashing at regular intervals of 50 to 70 times per minute is a distress signal.

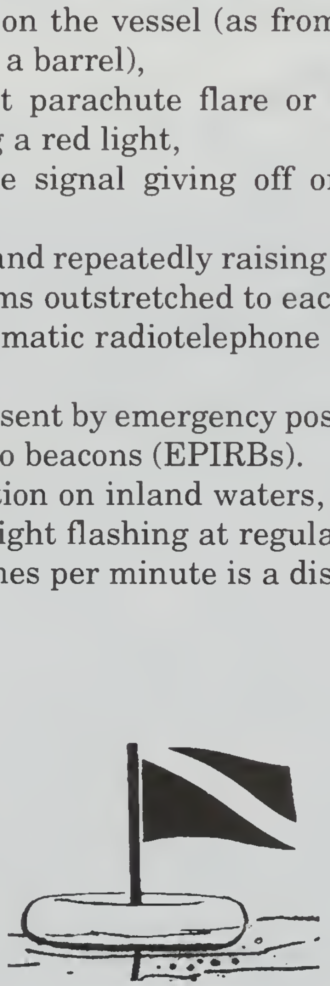


Fig. 6-32. The Commonly Used Diving Flag

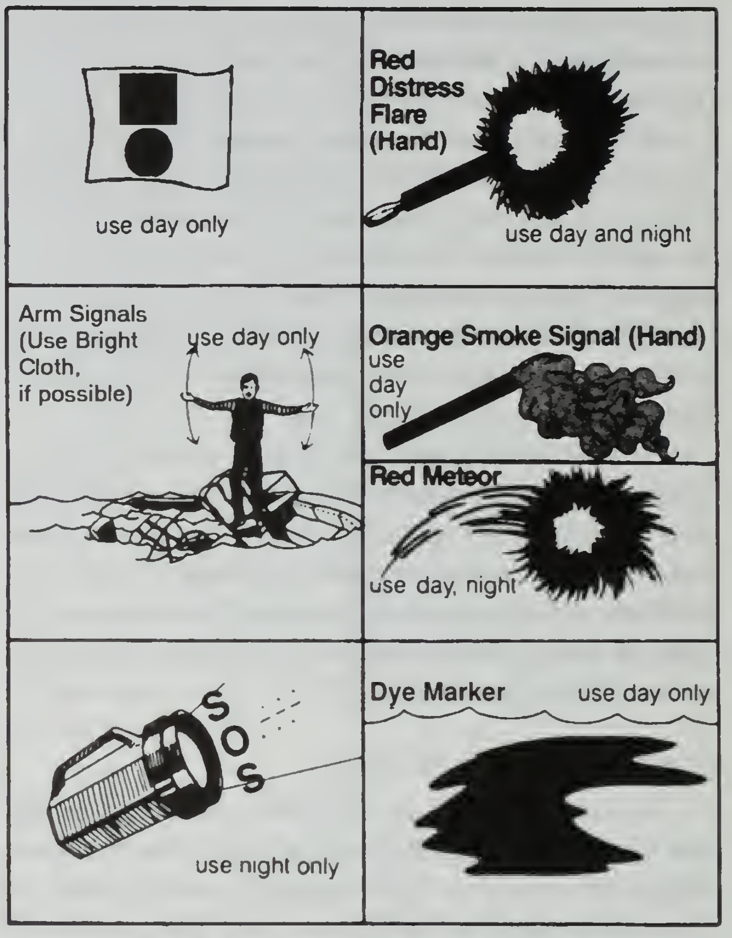


Fig. 6-33. Visual Distress Signals

DRAWBRIDGE SIGNALS

According to law, you request the opening of a drawbridge by using your radiotelephone. Start your call on channel 16. After contact with the bridge tender, switch to channel 13 and make your request.

Although not in the Navigational Rules, you can request the opening of a bridge by using your vessel's whistle. The signal is one prolonged blast followed by one short blast. The bridge tender replies with the same signal if the bridge is to be opened immediately. If it can't be opened immediately or is open and shall be closed promptly, the tender will reply with five short blasts. The five blast signal is repeated by the tender until you acknowledge it in some manner.

Because of heavy highway traffic, many drawbridges have scheduled opening times. They open only at regular intervals. The schedules are on signs near the bridges and have been published in the *Local Notice to Mariners*.

Some bridges have traffic light signals on their fenders. These flash amber from when the bridge begins to open to when it is completely open. They turn green when the bridge is fully open. When the bridge begins to close, the light turns red. When the bridge is completely closed, the light is turned off. If you request the opening of a bridge which has this light and it is not time to open it, the light will flash red until it is time to open.

To avoid placing bridges on opening schedules, the Code of Federal Regulations provides penalties of up to $1000 for causing a bridge to open unnecessarily. Do not request that a bridge be opened for any purpose other than to pass through its opening. Furthermore, if your vessel can pass under a drawbridge with appurtenances such as antennas and outriggers lowered and if these are not needed for navigation, you must lower them. After they are lowered, request that the bridge be opened. Antennas above the highest fixed point on your vessel must be collapsible.

PENALTIES

If you operate a vessel in violation of either set of rules, you are liable for a civil penalty of up to $5000 for each violation. You should notice that it is the operator and not the owner who is responsible when they are not the same person. When you charter a boat you are liable, not the chartering firm that owns the boat.

If you operate a vessel on U.S. waters in a negligent manner and endanger the "life, limb, or property of a person," you may be fined up to $1000. If you operate a vessel in a grossly negligent manner, you are liable for a fine of up to $5000 and imprisonment for as much as one year.

There are penalties, also, for failure to give help in marine casualties. When you give help, the "Good Samaritan" clause protects you.

Nothing in the rules ever requires you to place your own vessel in danger.

ATTENTION PARENTS

Take AIM* at the Future

High School juniors who have a strong interest in becoming officers in the U.S. Coast Guard may apply to attend the Academy Introduction Program at the U.S. Coast Guard Academy, New London, Connecticut. The U.S.C.G. Academy is the only one of the four Armed Forces service academies that offers appointments based solely on an annual nationwide competition, with no congressional appointments or geographical quotas.

Competition is open to all American citizens who have reached their seventeenth but not their twenty-second birthday, by July 1st of the entering year. In selecting students for admission, the Academy prohibits discrimination based on sex, race, color, national origin, or religion. Factors considered in the competition include SAT or ACT scores, high school standing, and leadership potential as demonstrated by participation in high school extracurricular activities. All candidates must pass rigid medical and physical fitness examinations. Majors are offered in:

- Civil Engineering,
- Electrical Engineering,
- Government,
- Management,
- Marine Science,
- Mathematical & Computer Science,
- Mechanical Engineering, and
- Naval Architecture & Marine Engineering.

For more information about the Academy or your child's opportunity to participate in the AIM Program, contact your instructor or:

Director of Admissions
U.S. Coast Guard Academy
New London, CT 06320
(203) 444-8501

1876

* Academy Introduction Mission

7

Piloting Your Boat

NAVIGATION is the science of knowing where you are and how to get to where you want to be. **PILOTING** is one kind of navigation. It is navigation in coastal waters, usually within sight of land. Navigation uses electronic devices and celestial bodies. Most piloting uses landmarks and aids to navigation.

In this course, we can only introduce you to piloting. We can, however, give you some useful tools and techniques.

After you have finished this course, you may find that you would like to study piloting in greater depth. The Auxiliary teaches two advanced courses; Basic Coastal Navigation and Advanced Coastal Navigation. Your instructor can tell you when and where these courses will be offered.

PILOTING TOOLS

Tools for piloting vary in cost from inexpensive to expensive. We advise you to keep your investment to a minimum. Limit yourself to the basic tools until you have an understanding of what you really need.

Your basic piloting tool kit should include:

- **CHARTS** of the area in which you boat,
- A good quality **MAGNETIC COMPASS** for your boat,
- A **COURSE PLOTTER** or **PARALLEL RULERS**,
- **DIVIDERS** or a **DRAFTING COMPASS**,
- A fine-lead (.5 mm) pencil with medium-soft lead,
- A good quality eraser.

In addition, you may want to include a binocular, a hand-held **BEARING COMPASS,** and some means of measuring water depth. You can measure water depth by a calibrated pole, a **LEAD LINE**, or an electronic depth sounder.

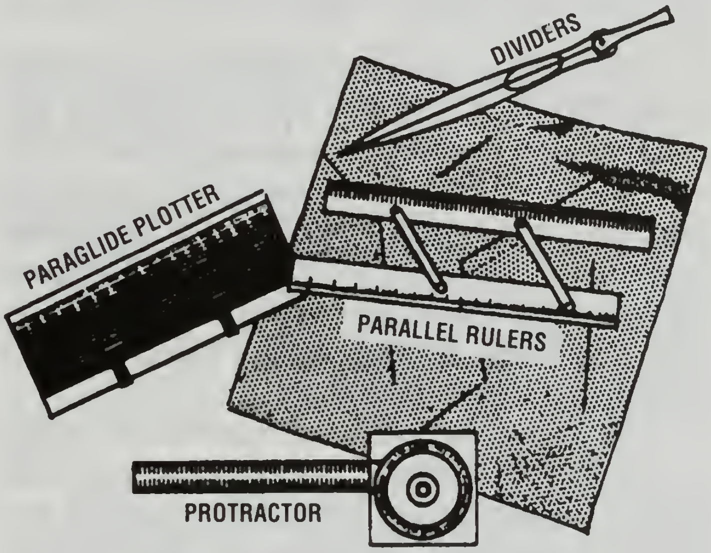


Fig. 7-1. Basic Piloting Tools

Binocular

Most authorities recommend a 7 X 50 binocular. It magnifies objects seven times. The diameters of its front (objective) lenses are 50 mm. This diameter is important in nighttime use. If it is less than 50 mm, it does not admit enough light for good vision in dim light. In a pitching and rolling boat, it is difficult to focus a binocular stronger than 7 X 50 on an object.

Electronic Tools

Later on you may wish to add electronic tools. These may include radar, satellite navigation, Loran-C, or other devices. Remember, though, no matter how sophisticated your electronic equipment becomes, there are times when you will use your mechanical tools.

MAPS AND CHARTS

The word *map* usually applies to a land area. The word *chart* usually applies to a water area. A chart is used to aid piloting and navigation.

Nautical Charts

Charts make navigation possible. A chart is a representation of a portion of the earth's surface showing information useful to mariners. Charts are printed on paper. Electronic charts are available and are growing in popularity. Usually, charts are drawn "to scale." This means that the sizes of objects in the drawings are proportional to their actual sizes.

Your charts may show both water and land areas. The land near the water may show considerable detail. This is especially true if the details can be of help to you in finding where you are, that is, your **POSITION**. Charts often include details such as the shape of a coastline, landmarks visible from the sea, marinas, harbors, small islands, radio towers, church steeples, and other objects.

Charts are technological marvels. The chapter on "Your Highway Signs" gave you some idea of the amount of information a chart contains. If you were to write out the information, it would take several large books to contain what is on a single nautical chart. Furthermore, the books would be hard to read and to interpret.

Availability of Charts

The National Ocean Service (NOS) of the National Oceanic and Atmospheric Administration (NOAA) publishes charts of U.S. Waters. You can buy them from NOS or authorized chart sales outlets such as marinas and marine supply stores.

Nautical chart catalogs list the available NOS charts. For example, *Nautical Chart Catalog 1* lists all NOS charts that cover the Atlantic and Gulf Coasts including Puerto Rico and the Virgin Islands. Nautical chart catalogs should be available where charts are sold.

Don't confuse the nautical chart catalogs with *Chart No. 1, Nautical Chart Symbols, Abbreviations, and Terms* that was discussed in "Your Highway Signs." Although it has the word *chart* in its title, it is a book. The catalog resembles a chart.

Dates of Charts

Information on charts changes from time to time. These changes appear in the *Local Notice to Mariners* published weekly by each Coast Guard District. As the information is outdated, your chart becomes less reliable. Be sure to buy and use up-to-date charts. A new edition of a chart cancels previous editions. "Revisions" contain less significant changes.

Charts have dates to help you be certain that you have the most recent versions. The store where you buy your chart should have a copy of the NOS publication, *Dates of Latest Editions.* Ask to see a copy before you buy a chart. Get a current chart and keep it up-to-date by posting changes as they are reported.

CHART FEATURES

If the world were flat, chart-making would be a much simpler process than it is. As you know, though, it curves. Charts are flat, however. How do you represent a curved surface on a flat chart?

Projections

One way to make a chart is to draw it on the surface of a globe. This accurately represents the earth's surface. It would not be very useful on a small recreational vessel, though. It would take a very large globe to show the area where you boat.

Another way of doing this is to use a mathematical concept called projection. This enables a chart maker to represent a curved surface on a flat sheet of paper.

Mercator Projections

Most nautical charts use the **MERCATOR PROJECTION** (fig. 7-2). Points on the earth's surface are projected onto a cylinder. After this, the cylinder is cut open and laid out to make a flat surface.

A chart made by Mercator's method is useful for piloting and navigation although it has severe limitations. One important feature is that all angles are represented correctly even in extreme northern and southern waters. This means that you can measure the angle of a

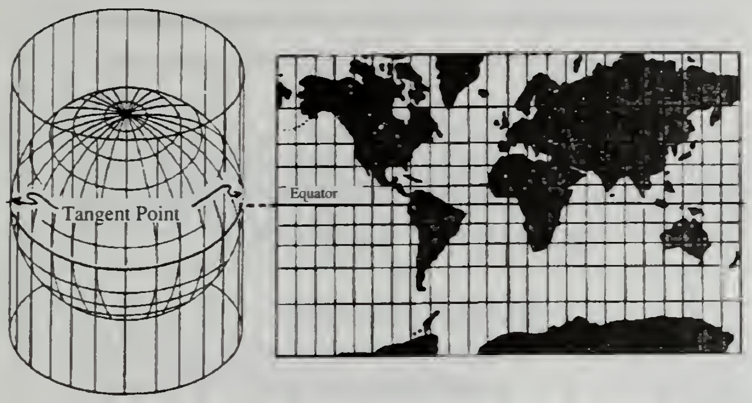


Fig. 7-2. Mercator Projection

COURSE LINE from one point to another directly on the chart. With this knowledge, you can head your vessel where you want to go.

Unfortunately, Mercator projections involve distortion in north-south and east-west directions. This distortion becomes greater the farther north or south you go from the equator. Thus, on a Mercator projection Greenland covers a much larger area than it should. This distortion makes Mercator charts nearly unusable in polar or near-polar areas. If the area covered by a chart is small enough, the distortion does not present a serious problem where most recreational boating occurs.

Polyconic Projections

Another common way to make a chart is by projecting the earth's surface onto a series of cones. This is a **POLYCONIC PROJECTION**. Great Lakes charts are most often conic projections since this projection gives less distortion at high northern and southern latitudes. Mercator projections are available, however.

Chart Scales

A chart can show a small area or a large one. The size of the area it represents depends on its scale. A harbor chart, for example, may have a scale of 1:20,000. If so, the drawing of an object is 1/20,000th the size of the object. A harbor entrance that is one inch wide on the chart would be 20,000 inches wide or about 3/10 of a mile.

If the chart's scale is 1:40,000, a one inch drawing represents an object about 3/5 of a mile wide. Conversely, the 3/10 mile wide harbor entrance would be only one-half inch wide on this chart.

Harbor and Coastal Charts

Harbor charts sometimes have a scale of 1:10,000. Such a chart can show detail, but it cannot cover a very large area. Coastal charts, on the other hand, usually have a scale of 1:80,000. They show larger areas with less detail.

There are even smaller scales (1:100,000; 1:1,000,000; etc.) for special purposes such as planning ocean **PASSAGES**. Some charts show an entire ocean on one sheet of paper. You should select your charts to give the greatest amount of detail (largest scale) you need for

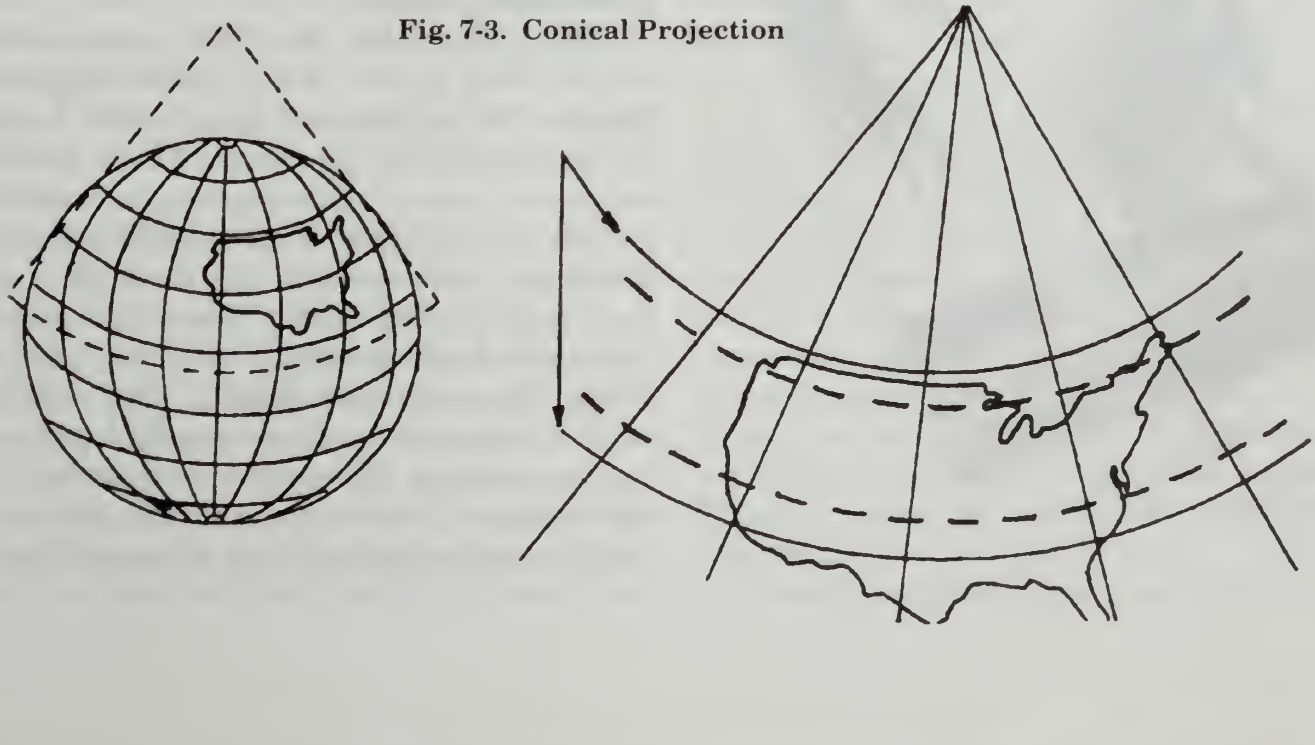


Fig. 7-3. Conical Projection

each portion of your cruise. Use small-scale, large-area charts for overall planning. Use large-scale, small area charts for maneuvering in harbors or other difficult areas.

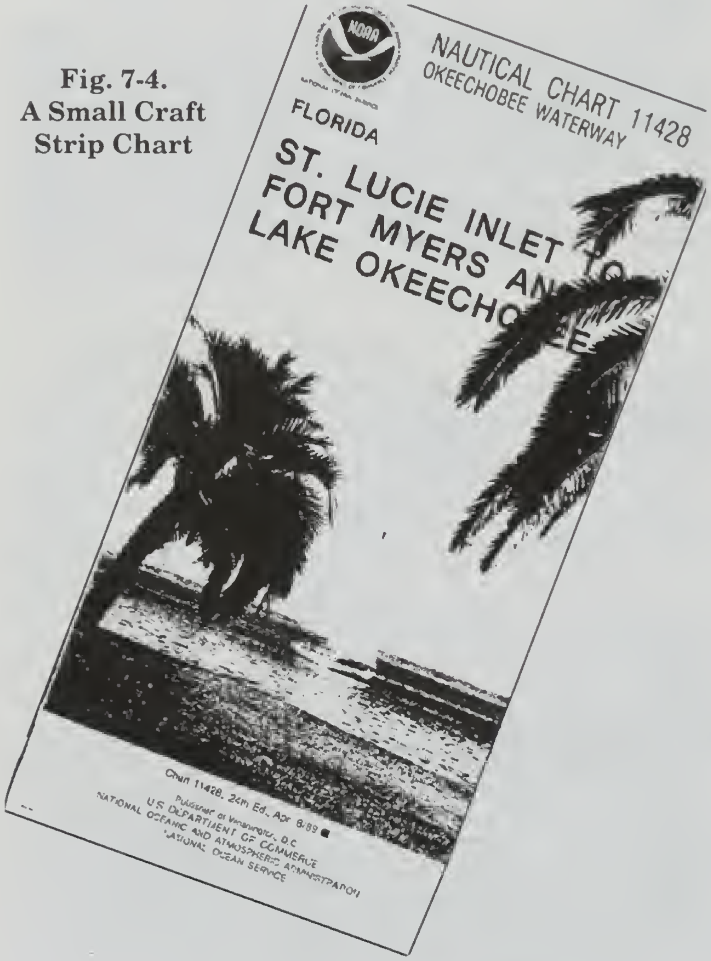
Which Chart is for You?

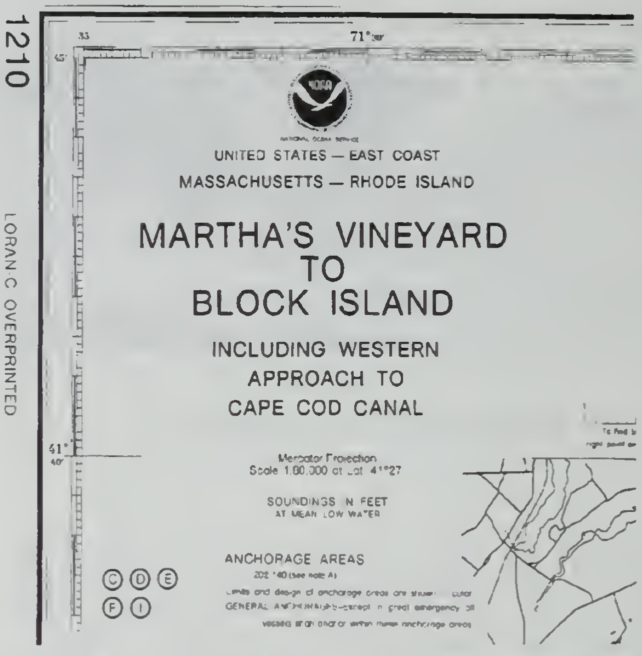
You can get some charts in either of two forms, "conventional" or "small craft" called "strip." Conventional charts are used on large, flat tables such as on the bridge of a ship. **STRIP CHARTS** are segments of conventional charts. Sections of larger, conventional charts are printed on smaller panels and enclosed in a folder. Strip charts are easier to handle on small recreational craft. Each panel gives you access to a small portion of the area.

Strip charts usually have a scale of 1:40,000. Often they have insets showing smaller areas. These insets may have scales of 1:20,000, 1:10,000 or even larger.

NOAA uses water-resistant paper for its charts. You may want to give your chart additional protection. Encase it in a plastic cover that will allow you to spread it out flat without worry about rain, spray, or wind.

Fig. 7-4. A Small Craft Strip Chart


NOAA
NAUTICAL CHART 11428
OKEECHOBEE WATERWAY
FLORIDA
ST. LUCIE INLET TO
FORT MYERS AND
LAKE OKEECHOBEE
Chart 11428, 24th Ed., Apr 8/89
Published at Washington, D.C.
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE



UNITED STATES — EAST COAST
MASSACHUSETTS — RHODE ISLAND

MARTHA'S VINEYARD
TO
BLOCK ISLAND

INCLUDING WESTERN
APPROACH TO
CAPE COD CANAL

Mercator Projection
Scale 1:80,000 at Lat. 41°27'

SOUNDINGS IN FEET
AT MEAN LOW WATER

ANCHORAGE AREAS

Fig. 7-5. The General Information Block of a Nautical Chart

YOUR CHART'S GENERAL INFORMATION BLOCK

Before you use a chart, read its **GENERAL INFORMATION BLOCK** (see fig. 7-5). This is sometimes called the chart block. It will tell you the chart's name. In the lower left corner of the chart you will find the edition number and date of publication.

The general information block will give you information such as the chart's projection, its scale, and its **DATUM**. Datum is a technical term for the benchmark from which a chart's vertical or horizontal measurements are made.

Horizontal Datum

Many charts use the North American 1927 datum. This datum is a geophysical point in Meade's Ranch, Kansas, from which horizontal measurements are made. These measurements are used to locate land masses and other geophysical features. With the arrival of space satellites, more precise measurements than those based on the 1927 datum are possible. So, many charts are being re-drawn using the North American 1983 datum. This results in very small, and for most practical purposes, inconsequential changes. You probably will never know if your chart uses the 1927 or the 1983 datum unless you read its legend block.

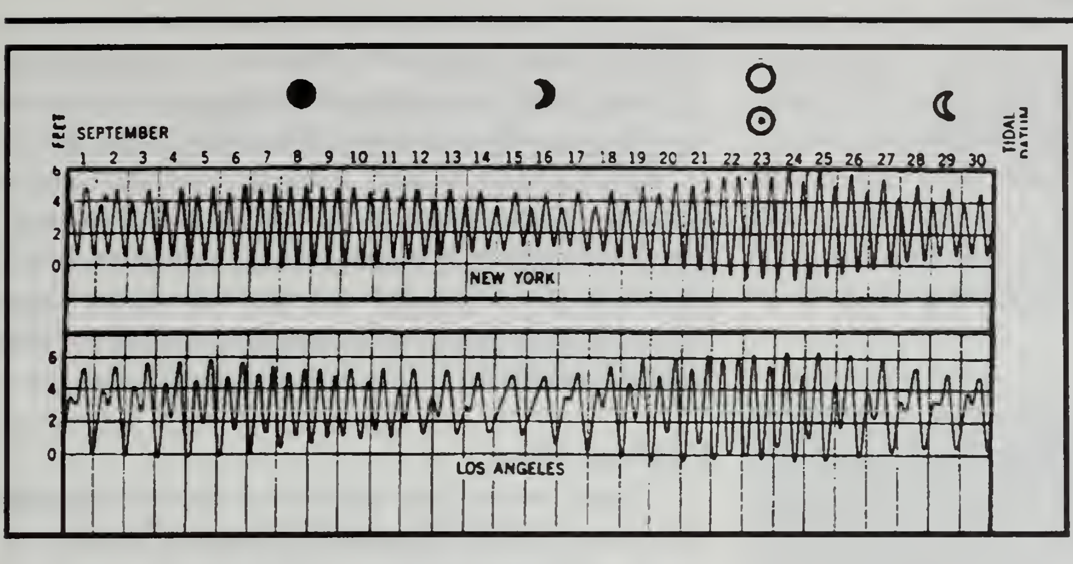


Fig. 7-6. Typical Tidal Variations

● New moon - ☽ First quarter
○ Full moon - ☾ Last quarter
⊙ Sun at autumal equinox
New York/East coast - Semidiurnal tides
Los Angeles/West Coast - Mixed tides

Vertical Datum

The vertical datum of a chart also has important meaning for you. It helps you know how much water is under your vessel. It also helps you know how much vertical clearance there is under a bridge (see fig. 7-7).

Tidal Water

Tides are the regular rise and fall of the level of the water. They are the result of the gravitational interactions of the earth, moon, and sun. The sun's effect is considerably less than the moon's since it is much farther from the earth.

In tidal water, depths change continuously. In some places, such as Alaska and the Bay of Fundy, the range of the rise and fall is greater than 30 feet. In others, for example Chesapeake Bay, it may be as little as six inches. Furthermore, the range differs according to the relative positions of the earth, moon, and sun.

On the Atlantic coast there are two sets of tides each tidal day. This means the water rises to high water twice each tidal day. It also falls to low water twice daily. It is a **SEMIDIURNAL** tide. Both high waters are about equal in height as are the low waters. A "tidal day" is about 24 hours and 50 minutes.

On the Pacific coast, there are also two sets of tides each day. One high tide is higher than the other, and one low tide is lower than the other. Such tides are **MIXED TIDES**. Along the Gulf Coast and in the Great Lakes, the tides are **DIURNAL**. In diurnal tides there is only one high and one low tide each day.

Obviously, some way of helping mariners know how much water may be under their keels at any particular time is necessary. Tide tables published by NOS and widely reprinted offer a solution to the problem.

The datum used for heights of objects on land and over water is **MEAN HIGH WATER (MHW)**. This is the average (mean) level of all high tides. To get this average, all unusual conditions such as storms are excluded. The clearances for bridges appear on charts. These are the distances from the water's surface at mean high water to the lowest clearance under the bridge. Remember, this is the clearance at *mean high water.*

In the past, the datum for charted water depths differed according to the type of tides in an area. On the Gulf Coast and the Great Lakes, where there is only one low tide each day, the datum was **MEAN LOW WATER** (MLW). On the east coast the datum was also mean low water and was the average of all the low tides. On the Pacific coast where the heights of the two low waters each day are unequal, the datum was (and is) the lower of the two. This datum is **MEAN LOWER LOW WATER (MLLW)**.

Charts are being revised and they now use one datum, *mean lower low water*. Although the name of the chart datum has changed, indicated water depths will remain the same. On the east and Gulf coasts and the Great Lakes, MLLW will be the average of the low waters. On the Pacific coast, only the lower of the two daily low waters will be averaged as in the past.

Remember that datums are averages. At times there will be less vertical clearance under bridges and less water depth over shallows than shown on your chart.

Tide Tables

The National Ocean Service (NOS) publishes tables showing the times and levels of predicted tides for the Atlantic, Gulf, and Pacific coasts and for tidal rivers. Although these tables are dependable, do not follow them unthinkingly. Local conditions such as storms, wind direction and strength, and barometric pressure affect tidal levels.

The depths of water shown on your chart are averages. Some low tides are higher than the charted depths and some are lower. Tide tables tell you when to expect the next high or low tide. They also tell you how much higher or lower than the mean the tide is *predicted* to be. Add or subtract this difference to the charted depth of the water. This will let you know how much water *may* be under your keel at the next high or low tide. While doing so, don't forget to consider the amount of water your boat **DRAWS**. Some of your boat is below the water's surface.

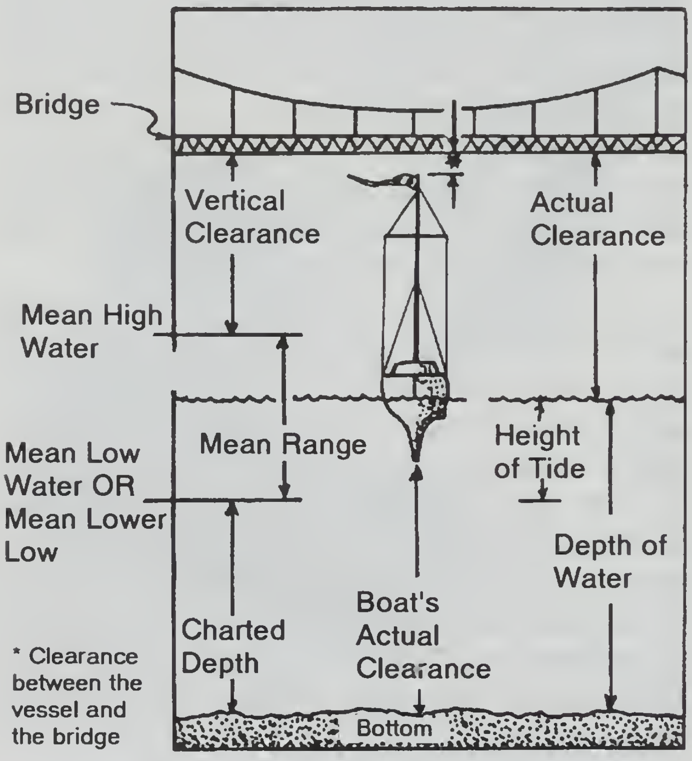


Fig. 7-7. Vertical Datum

Western Rivers

There are no tide tables for western rivers. However, NOS **Nautical Chart Catalog 4** lists available bulletins of lake and river pool levels by month. Some newspapers give pool levels daily. River pools are the lakes formed by dams.

OTHER CHARTED INFORMATION

Besides heights and depths, charts also describe types of bottom materials, using special abbreviations. This information is useful if you are trying to select a place to set an anchor.

Grd	*Ground*
S	*Sand*
M	*Mud; Muddy*
Oz	*Ooze*
Ml	*Marl*
Cy:cl	*Clay*
G	*Gravel*
Rk;rky	*Rock;Rocky*
P	*Pebbles*
St	*Stones*

Fig. 7-8. Types of Bottoms

Your chart also shows obstructions and other hazards.

Symbols tell you what to be ready for and what to avoid. As you already know, your chart also shows aids to navigation.

Water Depth

Shallower water is light blue on a chart. Deeper water appears as white. This gives you a ready visual reference without your having to look at the numbers which show depth. Remember, though, that the blue and white water vary in depth depending on the scale of the chart. As a rule of thumb, switch to a larger scale chart when you move into the blue.

Most often, water depths are in feet. Some charts, though, report depths in **FATHOMS** (a fathom is six feet or about two meters). Others use metric measurements. NOS is changing its charts from the English system to the metric system.[1] Read your chart's general information block to see what units it uses for reporting depths and heights.

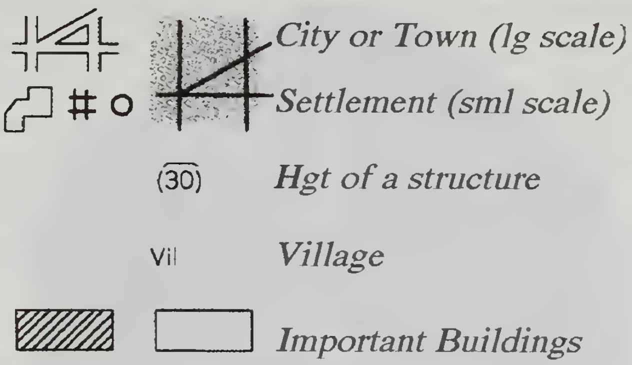


Fig. 7-9. Some Charted Landmarks

Notes

Charts also contain notes on their borders and in other clear spaces. These give you important safety information and information of a more general nature such as anchoring and precautionary areas. Read them.

For example, Page G of Chart 11451 shows "Moser Channel (see note)." The note says, "Moser Channel—Overfalls that may swamp a small boat may occur at the bridge." This means that during certain tidal changes, tidal currents at this point oppose each other and create an overfall. The note warns unsuspecting mariners that their boats may run head-on into an unexpected waterfall. How much better it is to know this in advance than to learn it the hard way. *Read the notes on your chart.*

Shore Details

Charted details ashore include easily recognized structures. Water towers, church steeples, and radio towers are examples of these structures. Land contours are often charted. Bridges are described in detail.

The shoreline contour is another important feature. It is usually printed a golden color. If the shore is swampy or covers and uncovers with changes in water level, it is light green.

Keep in mind that structures that were once prominent enough to appear on your chart may no longer be there. Sometimes you can't see them because newer, larger buildings screen them from view. The process of keeping charts up-to-date is continuous. The Coast Guard Auxiliary assists in it.

Aids to Navigation

You learned to recognize and use aids to navigation in the chapter on "Your Highway Signs." These structures, both fixed and floating, serve as signposts, beacons, directional signals, and warnings of danger. They are your most important piloting aids.

YOUR MAGNTIC COMPASS

Select a **COMPASS** to suit your boat. Power boats need compasses built to withstand the vibrations and pounding of boats moving at high speeds. The compass of a sailboat must be able to operate satisfactorily when the boat heels over at an angle.

Features of a Good Compass

A marine compass contains an oily or alcohol-based liquid. This dampens vibrations and oscillations and keeps the compass card from swinging rapidly as your boat bounces. The compass should have a bellows chamber to allow for expansion and contraction of the fluid as temperatures change.

---

[1] NOS began to convert chart measurements to the metric system in 1992. It is estimated that the changeover will require 10-15 years. Water depths will be given in meters instead of feet or fathoms. Bridge elevations will be in meters. Except on river charts, distances will continue to be given in nautical miles.

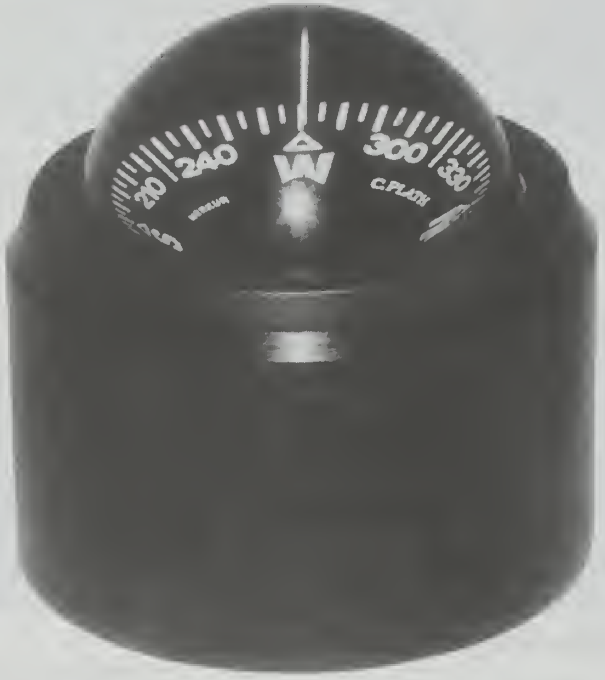


Fig. 7-10. Small Boat Magnetic Compass
(Photo Courtesy of C. Plath and Company)

Protect your compass from excessive heat and direct sunlight. A compass may leak fluid from a ruptured seal if it overheats. Without its fluid, it is unusable.

You will find it useful to have a light so you can read the compass at night. A good compass comes with an internal red light. It will not impair your night vision.

Large compasses usually are more stable and more finely calibrated than small compasses. Select one that is as large as practical for where you will mount it.

Installing Your Compass

Install your compass where it will be easily visible from the helm. If possible, locate it so you can sight over it in all directions. This makes it useful in determining your position.

Above all, install your compass so its central pivot and **LUBBER'S LINE** are parallel to your boat's keel. If you do not install your compass this way, it will have a constant error.

Locate your compass as far as possible from radios, other electronic instruments, or masses of ferrous (iron) metal. This is not usually a problem on boats with outboard motors. On inboards it may be a significant problem. Watch your compass card while you are at a pier. Does it move when you turn on an electric or electronic instrument? If so, move either the compass or the instrument.

Adjusting Your Compass

After you install your compass, take your boat to an area with several charted landmarks and one or more *fixed* aids to navigation (not buoys) which can be used with the landmarks as ranges. Align and point your vessel towards each range and read your compass. Compare these readings with the directions as measured on your chart. If they vary only two or three degrees from what they should be, ignore it. Most people can't read such small differences on their compasses, nor steer a course that accurately anyway. If the differences are considerable, make a note of them. As explained below, you can use them to adjust the courses you will steer.

A good compass has internal adjustment magnets to adjust it for magnetic influences aboard your boat that cause compass error. Don't try to adjust your compass unless you have patience and special knowledge. Compass adjusting experts can usually be found in the Yellow Pages.

POSITION ON THE EARTH'S SURFACE

Navigation involves getting from where you are to where you want to be. To do this, you must be able to locate both your present position and the position to which you wish to move.

Great Circles

Lines of **LATITUDE (LAT)** and **LONGITUDE (LO)** provide one means of describing points on the earth's surface (see figs. 7-11, 7-12, and 7-13). These lines are made by passing imaginary planes (flat surfaces) through the earth. If a plane passes through the center of the earth, its intersection with the earth's surface is a **GREAT CIRCLE**.

Parallels of Latitude

The great circle formed by passing a plane through the earth's center perpendicular to the earth's axis is the **EQUATOR**. Other lines formed by passing planes through the earth perpendicular to its axis are **PARALLELS OF LATITUDE**. They are parallels since each is parallel to every other line of latitude, including the equator.

Latitude lines encircle the earth in an east-

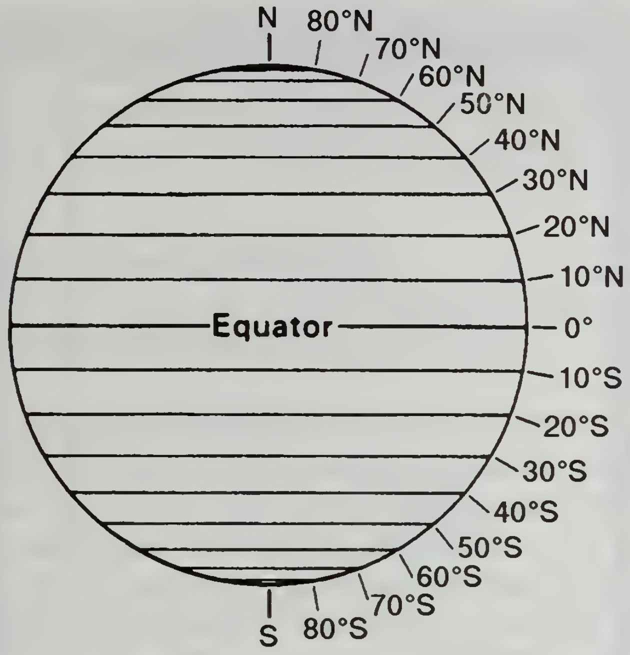


Fig. 7-11. Parallels of Latitude

west direction. They measure angular distances north and south of the equator.

Angles are measured in degrees. Each degree can be divided into 60 minutes (60') and each minute can be divided into 60 seconds (60"). Degrees are shown by ° while minutes are ' and seconds are ". In piloting we use tenths of minutes or seconds according to the scales on the charts in use.

To illustrate their use, draw a line from the earth's center to the point where it intersects the equator as in figure 7-12. Next, draw another line from the earth's center to a second point directly above the first point and on another line of latitude. The angle between these lines describes the position of the second point in relation to the equator. The second point can be either north or south of the equator. In figure 7-12, the point is at 60° N latitude (abbreviated "Lat"). In figure 7-13, the angle shows that Greenwich, England is at 51° 28'N latitude.

The angle between the two lines can vary from 0° to 90° since the equator is 0°, and the poles are Lat 90°N and Lat 90°S. A point halfway between the equator and either the north or south geographic pole is at an angle of 45°. It is either Lat 45°N or Lat 45°S depending on whether it is north or south of the equator.

Longitude Lines

Planes that pass through both geographic poles form great circles on the earth's surface. These are called lines of longitude (abbreviated "Lo") or **MERIDIANS**. On one side of the earth the lines are called the upper branches. On the opposite side they are called the lower branches. Meridians run north and south through the earth's poles. They measure east-west angular distances. The meridian that passes through Greenwich, England is the upper branch of the **PRIME MERIDIAN**. It's longitude is 0°.

Now, imagine a line drawn from the center of the earth to the intersection of the prime meridian with the equator such as in figure 7-13. Imagine, too, another line drawn from the

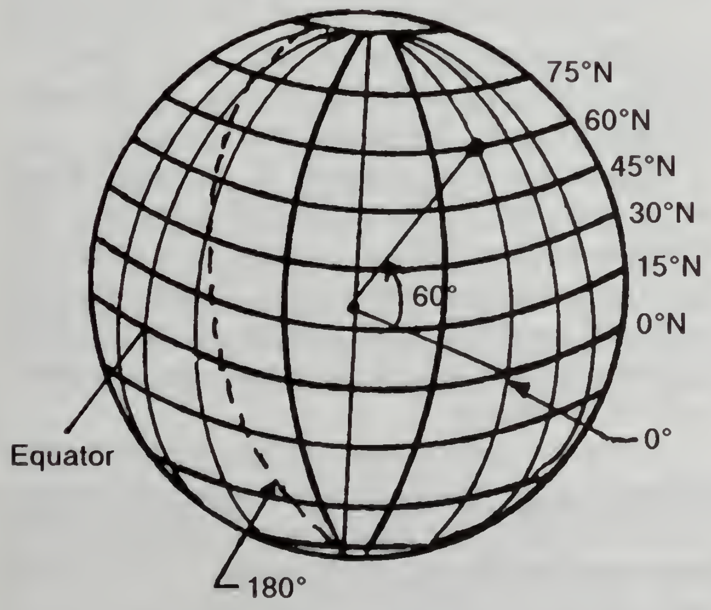


Fig. 7-12. Measuring Latitude

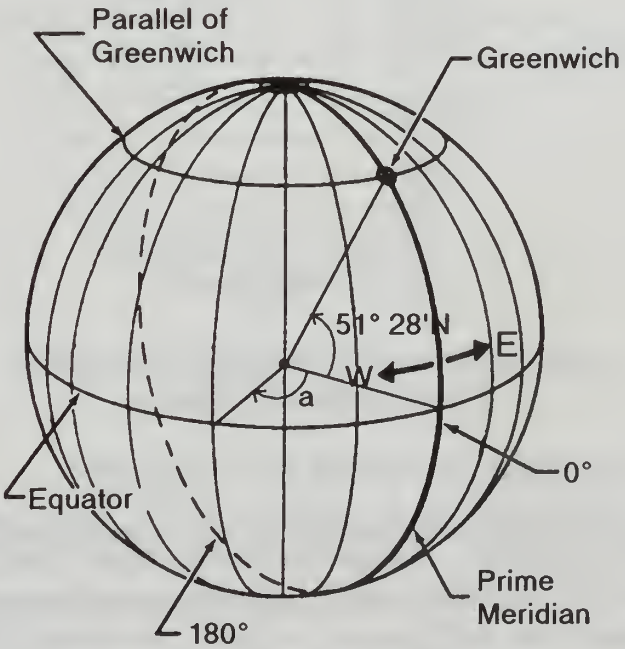


Fig. 7-13. Meridians of Longitude

center of the earth to a point where a different meridian intersects the equator to form angle "a." Angle "a" between these two meridians tells the position of the point relative to the prime meridian. The position may be east or west of the prime meridian.

If you go west from Greenwich one-quarter of the way around the earth, you are at Lo 90°W. If you go east one-quarter of the way around the earth, you are at Lo 90°E. If you go half-way around the earth, you are at Lo 180°. Lo 180°E and Lo 180°W are the same meridian. Lo 180° is approximately the International Date Line (see the line of dashes on figure 7-13.). It is at Lo 180° except where it is drawn to exclude or include bodies of land. It is drawn west of Alaska, for example, so all of Alaska has the same calendar date.

Location on the Earth's Surface

You can describe any point on the earth's surface by its latitude and longitude. If a vessel's position is 44° 00'N, 80° 00'W, as in figure 7-14, there is only one place on earth it can be. It is in Lake Huron. Greenwich, England is located at Lat 51° 28' N, Lo 0° 00'.

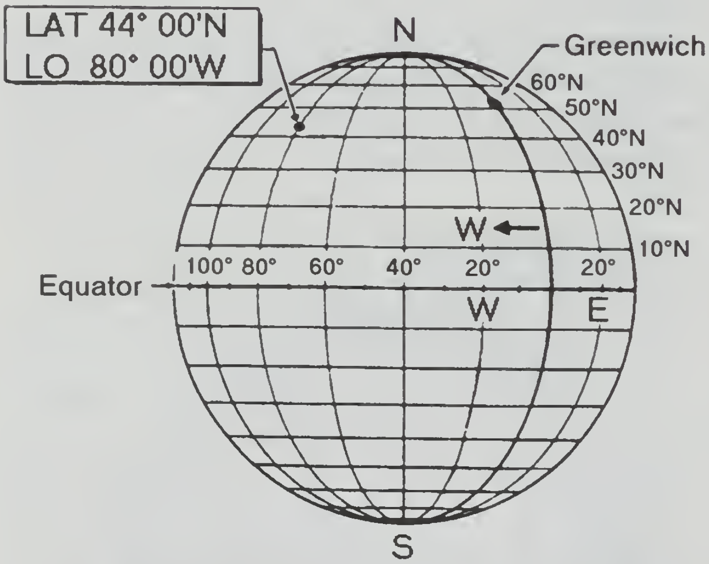


Fig. 7-14. Latitude and Longitude Provide a Coordinate Grid System.

LOCATING A POINT ON A CHART

On most charts, north is at the top. Parallels of latitude extend across the page. Meridians of longitude run up and down the page. Along the margins of a chart are black and white scales showing degrees, minutes, and tenths of minutes or seconds. The scales on the left and right are latitude scales. Those on the top and bottom are longitude scales.

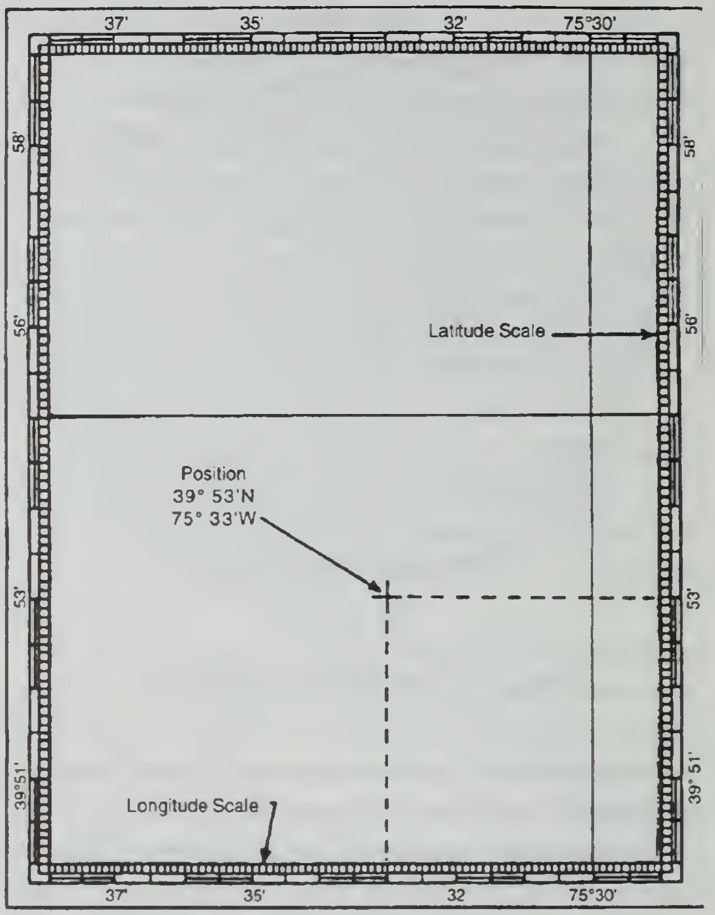


Fig. 7-15. Locating a Position on a Chart

You can describe any point on a chart by using the latitude and longitude scales. Figure 7-15 illustrates their use in determining a position.

DISTANCE ON THE EARTH'S SURFACE

You have probably heard the term **NAUTICAL MILE** and wondered why it is used instead of the more common unit of distance, the statute mile. There is a good reason.

There are 360 degrees in a circle. Each circle has 360° × 60 or 21,600 minutes. The distance covered by one minute on a great circle is one nautical mile. It is 21,600 minutes or 21,600 nautical miles around the earth. This makes the nautical mile a convenient measure of distance.

All great circles are not the same length, however, since the earth is not a perfect sphere. In July 1, 1959, the length of one nautical mile was set officially at 1,852 meters (about 6,076 feet). This is 1/21,600 of the distance around the earth at the equator. Since a statute mile is 5,280 feet (about 1,600 meters), one nautical mile equals 6076 ÷ 5280 or 1.15 statute miles. Thus, a nautical mile equals about 1-1/7 statute miles. A **KNOT** is a speed of one nautical mile per hour.

MEASURING DISTANCE

There are two ways to measure the distance between two points on a chart.

Use the Chart's Scale

Most charts have distance scales. These show distances in nautical miles, statute miles or kilometers, and yards or meters. You can use these scales to measure the distance between two points on the chart. To do so, use your dividers. Set one leg of the dividers on one point and the other leg on the second point. Now move your dividers to a scale such as shown in figure 7-16.

Put one leg of the dividers on one of the whole division points, that is, on 1, 2, 3, etc. Select a division point that will place the other leg of the dividers somewhere within the divided scale at the left end of the scale. The whole division point is the number of nautical miles, statute miles, kilometers, yards, or meters. The finer divisions to the left are tenths. On the "yard" scale, the finer divisions are each equal to 100 yards.

Use the Latitude Scale

The second way to measure distance on a chart is by use of its latitude scale. Again, set your dividers to extend from one chart point to another.

Now, move your dividers to the *latitude* scale near the mid-point of the latitudes of your points as in figure 7-17. Place one leg of the dividers on a minute or a degree mark on the latitude scale. Place the other leg above it on the latitude scale as in figure 7-17. You can now count the minutes and tenths of minutes between the two points. Remember, one minute of latitude equals one nautical mile. In making your measurement, use points near the same latitude as points A and B.

If the distance between the two points you are measuring is greater than the span of your dividers, set the span of the dividers equal to one nautical mile by using the latitude scale of the chart. Now "walk" the dividers from one end of the line joining the two points to the other end keeping count of the number of nautical miles you have measured. When you get near the end of the line, reduce the span of the dividers to equal the length of the last segment. Apply the dividers to the latitude scale to see the length of the segment and add its length to the number of whole nautical miles you counted.

The longitude scales on a chart *cannot* be used to measure distance. Figure 7-14 shows that although latitude lines are spaced at equal intervals, longitude lines are closer together near the earth's poles than they are at the equator. Use the latitude scales on the right and left of a chart to measure distance. Do not use the longitude scales at the top and bottom

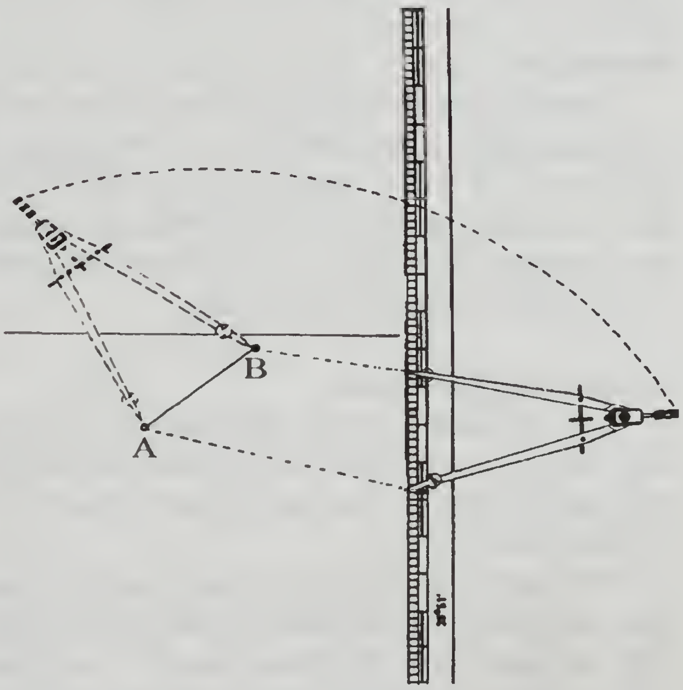


Fig. 7-17. Using the Latitude Scale to Measure Distance

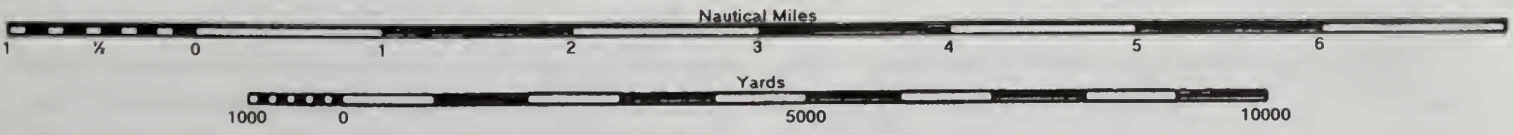


Fig. 7-16. Distance Scale

of the chart.

On small scale polyconic charts, you can measure large east-west distances most accurately by using the distance scale.

Use a Piece of Paper

If you don't have dividers, you can use a piece of paper to make your measurement. Make a mark on the edge of the paper. Place this on one of the points. Align the paper's edge with the two points and put another mark at the second point. You can now move the paper to the latitude scale and read the distance.

COURSE PLOTTING

An important feature of Mercator and large-scale polyconic charts is that angles are represented correctly. Draw a line on a chart from where you are to where you want to go. The angle it makes with due north is the direction you should go to get where you want to be. In addition, the length of the line represents the distance you have to travel to get there.

Direction

You measure direction clockwise from north and express it in degrees. East is 90°, south is 180°, west is 270°, and north is 360° or 0°. Since meridians always run north and south, the direction of a line is the clockwise angle between a meridian and the line.

Measuring Direction

You can measure the direction of a course line drawn on a chart in several ways. The two most common ones use a course plotter or parallel rulers.

Whichever method you use, the first step is to estimate the direction of the course line. The estimate will help you avoid a common error. When you make your estimate, remember that a line has two ends. One end points in the direction you are interested in. The other points in the opposite direction. These two directions are 180° apart which means they are **RECIPROCALS**.

A direction between north and east is between 0° and 90°. Between east and south the direction is between 90° and 180°; between south and west it is between 180° and 270°; and between west and north it is between 270° and 360°(0°).

Using a Course Plotter

A simple way to measure the direction of a course when you are on a small vessel is by a course plotter. Align any of the lines or long edges of the plotter with the course line. Slide it along the line until the bull's-eye is on a meridian or a parallel and read the direction. Complete directions for using a course plotter are in Appendix C of this book.

Using Parallel Rulers

You may also measure the direction of a line by using the *nearest* **COMPASS ROSE**. There are several ways to do this. If you use parallel rulers, align one edge of the rulers with the line and then *walk* the rulers to the nearest compass rose. The edge of the ruler should pass through the center of the compass rose. You can then read the direction from the *outer* edge of the compass rose.

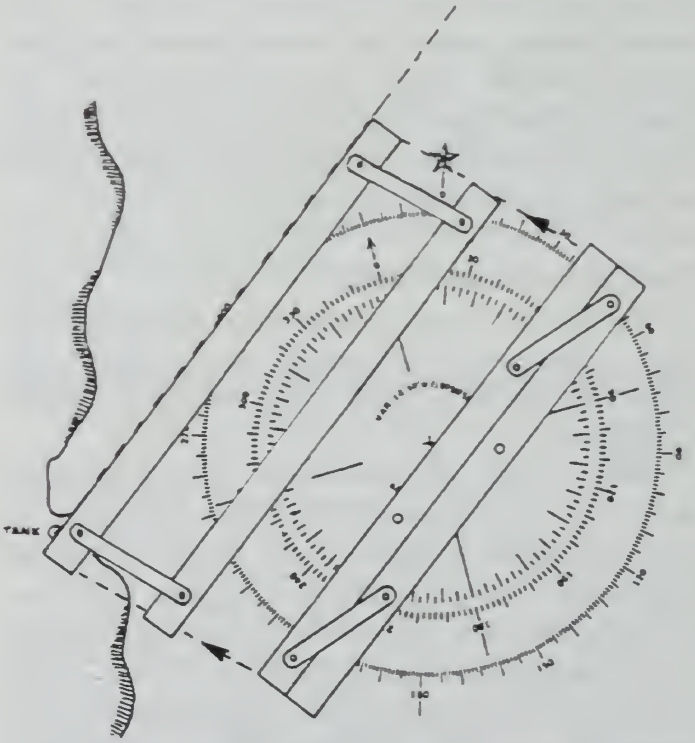


Fig. 7-18. Using Parallel Rulers to Measure Direction

The edges of parallel rulers may not be exactly parallel to each other. However, you can move either edge parallel to itself. This means that when you align one edge with the

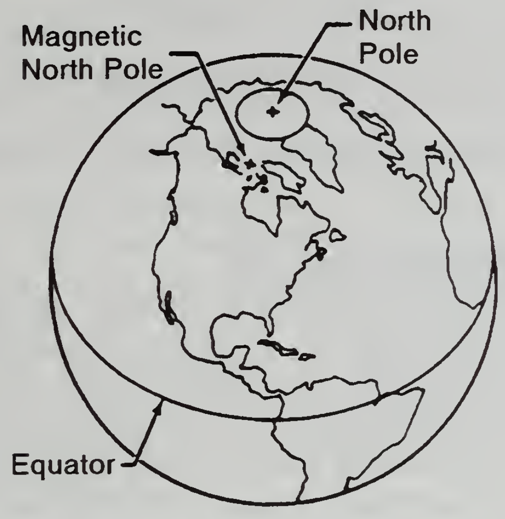


Fig. 7-19. Relative Position of Poles

line you are measuring, move this same edge to the center of the compass rose. Use this edge to make your measurement.

SOURCES OF COMPASS ERROR

Even if you read your compass correctly, your reading may be in error. Two sources of compass error are **VARIATION** and **DEVIATION**.

Variation

The earth's core is ferrous iron. One end of it is the north magnetic pole. The other is the south magnetic pole. Unfortunately, the magnetic poles are several hundred miles away from the geographic poles (see fig. 7-19). A compass needle points to the magnetic north pole, not the geographic north pole known as "true" north. The failure of a compass to point to true north is an error called variation.

It should be noted that marine compasses do not really "point." Beneath the card of a marine compass there is a small bar magnet. This magnet aligns itself with the earth's magnetic field and remains aligned as the vessel turns. The card to which the magnet is attached may appear to turn but does so only in relation to the vessel. The card remains in the same position relative to the earth. Thus the compass is said to "point" toward magnetic north.

Variation is either easterly or westerly—your compass points either east or west of where true north really is. You can find the amount of variation for an area by referring to the compass rose printed on each nautical chart. In figure 7-20, the amount of the variation was 15° W in 1985. At that time it had an annual increase of 3'. Variation changes from place to place. Thus, if your chart has two or more compass roses, each may show a different variation. Use the variation noted on the compass rose closest to your position.

You will notice that the compass rose has two protractor scales (fig. 7-20). The outer scale represents direction as determined by true north. The other scale represents direction, taking variation into account. It shows **MAGNETIC NORTH**.

The *innermost* gradations on a compass rose have more historical interest than practical value for recreational boaters. They are "compass points." Since there are 32 points on the compass, each point represents 11.25°.

Deviation

Variation is the same for all vessels in an area. Deviation, though, varies from vessel to vessel within the same area. It is compass error caused by magnetic fields aboard the vessel. Your engine, steering wheel (including its spokes), dashboard instruments, electronic equipment, and bundles of wires may have

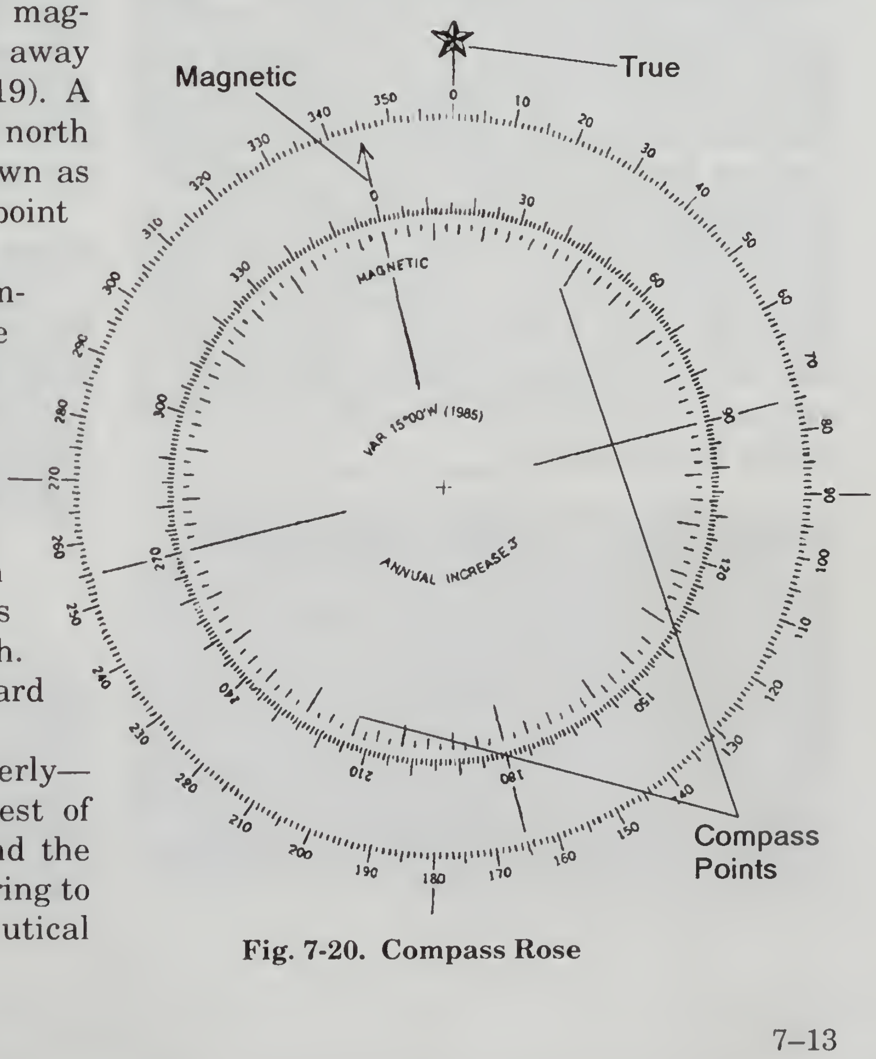


Fig. 7-20. Compass Rose

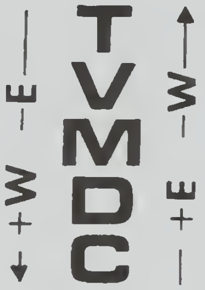


Fig. 7-21. A Memory Device for Correcting and Uncorrecting Compass Readings

magnetic fields. Your radio's speaker has an especially strong magnetic field. These local magnetic fields can cause your compass to deviate and not to point toward magnetic north.

Some vessels do not cause deviation in their compasses. Outboard motors usually do not influence a compass. They are too far from it and have less iron in them than inboards or stern drives. If your compass is far enough away from your electronic equipment and other magnetic fields aboard your vessel, it should have little deviation.

The local magnetic fields on your vessel interact with the earth's magnetic field and the magnetic field of your compass. These interactions cause errors called deviation. Deviation differs with the **HEADING** of your boat.

Since your boat carries its local magnetic fields with it, deviation does not change from place to place. If the effects of deviation are less than one or two degrees, ignore them. If they are larger, you may want to construct a **DEVIATION TABLE**. You can use the data in your deviation table to correct your compass. Regrettably, building a deviation table is beyond the scope of this course. You can learn how to do it in Basic Coastal Navigation or Advanced Coastal Navigation, or you can have it done professionally.

CORRECTING A COMPASS READING

You measure the direction of a course on a chart as an angle between the course and true north. This is easy to measure on a chart. Unfortunately, though, when you try to head your boat to where you want to go, your compass does not point toward true north. Instead, it points in some other direction as a result of variation and deviation. How can you tell the direction to head your boat?

You can *correct* a compass reading to tell its direction with reference to true north. You can also *uncorrect* a true heading to tell you the compass direction in which to head your boat.

A Helpful Memory Aid

Figure 7-21 shows a memory device that makes correcting or uncorrecting a simple procedure. The letters TVMDC stand for True, Variation, Magnetic, Deviation, and Compass. There are several ways to remember TVMDC. One is *T*ele-*V*ision *M*akes *D*ull *C*hildren.

There are arrows on either side of the memory device. The ones on the left show that when you are uncorrecting a true heading, you add westerly variations and deviations, and subtract easterly ones. The arrow on the right shows that when you are correcting a compass reading you add easterly variations and deviations, and subtract westerly ones.

To simplify, the memory device says, "*T*ele-*V*ision *M*akes *D*ull *C*hildren, add *W*onder." So, when converting from true headings to compass headings, add westerly variations and deviations. It follows then, that you would subtract easterly ones. If you are going from compass to true, do the opposite. Add easterly variations and deviations, and subtract westerly ones. This means that all you need to know is TVMDC + W and you can work out the rest.

Some Examples

Let's use an example. In an area in which the variation is 5°W you measure a course heading on your chart and find it is 047°. Since you are uncorrecting your heading and converting from true to compass, you first add the westerly variation.

$$047° + 5° = 052°M$$

This is your magnetic heading. Use an "M" to show it.

You then look at your deviation table and find that for a course of 052°M. Your deviation is 8°E. You now subtract the easterly deviation.

052°M - 8° = 044°C

This is your compass heading. Label it with a "C."

Here's another example. Suppose the variation in the area where you are boating is 7°W and your compass reads 104°. According to your deviation table the deviation for a compass heading of 104° is 10°W. What is your true heading? This example asks you to correct a compass reading. This means that you will add easterly deviations and variations and subtract westerly ones.

104°C - 10° = 094°M

You now subtract the westerly variation.

094°M - 7° = 087°

Your true heading is 087°. Notice that you do not use a "T" to show it. If the letter is missing, you assume the direction is true.

POSITIONING

The most common navigation problem is locating your position. You may want to know yours for a variety of reasons. If there is an emergency, you will want to tell the Coast Guard where you are. Or, you may want to know where you are to see if you have enough fuel to get to where you want to go.

Line of Position

A **LINE OF POSITION (LOP)** is a line on a chart drawn through the position of your vessel. By itself, an LOP does not tell you where you are. All you know is that you are somewhere along the line. If you can determine two lines of position, you can tell where you are. You are at their intersection. (See figure 7-22 which shows two lines of position.)

A Range LOP

A range can be used to determine an LOP. You learned about ranges in chapter 5, "Your Highway Signs." If you can line up two charted objects, you can draw a line from the objects toward your vessel. You are somewhere along this line. Just where, you don't know. Although you may not know where you are, you now know where you are not!

Establishing a Fix

If you can draw two LOPs on your chart while you are at the same point, you can find your position. You are at the point where the LOPs intersect. You have made a **FIX** and have determined your position. You can also get a fix by passing close aboard a charted object such as an aid to navigation. You do not usually use a buoy to determine a fix since it may be off station. Use one only if no other fixed ATON or landmark is in the area.

Ranges and Fixes

A range can give you an LOP. Two range LOPs sighted from the same position give you a fix. It is not often the case, though, that you can sight two ranges in this way. Instead, you must determine at least one LOP in another way.

Bearings and Fixes

You will most often get your LOPs using a magnetic compass. You can use either a hand-held bearing compass or your boat's compass. Select two or more identifiable landmarks or aids to navigation that appear on your chart. If you use only two marks, select them so the angle between them, as seen from your position, is as close to 90° as possible.

Take your readings by pointing your hand-held compass at the marks. The direction of a mark is its **BEARING**. If you use your vessel's compass, head your vessel toward the marks and note their bearings. You will use these bearings to determine your position.

Charting Your Position

After you have determined the bearings of two or more marks, the next step is to correct them. If you use a hand-held bearing compass, you usually assume that its deviation is zero. If you use your boat's compass, read the deviation from your deviation table. In either case, you determine variation from the compass rose on your chart.

Suppose that at 1215 you took bearings on a tank and a monument by using your boat's compass (see fig. 7-22). Suppose, also, that variation for the area is 12°E. Suppose, too, that the bearing to the tank is 088°C and to the monument is 176°C. Let's also suppose that your deviation table shows that for a bearing of 088°C the deviation is 3°W and for a compass bearing of 176°C it is 3°E. Your first step is to correct each compass bearing to a true bearing.

088°C - 3°W = 085°M
085°M + 12°E = 097°

The bearing of 176°C must also be corrected:

176°C + 3°E = 179°M
179°M + 12°E = 191°

Drawing LOPs. After you have determined the true directions of the two marks, you can use your parallel rulers and a compass rose to determine where to draw the LOPs. To draw the first LOP, place one edge of the ruler so it passes through the center of the rose and 097° on the outermost scale. Now, "walk" the ruler to the tank and draw a line back toward your position.

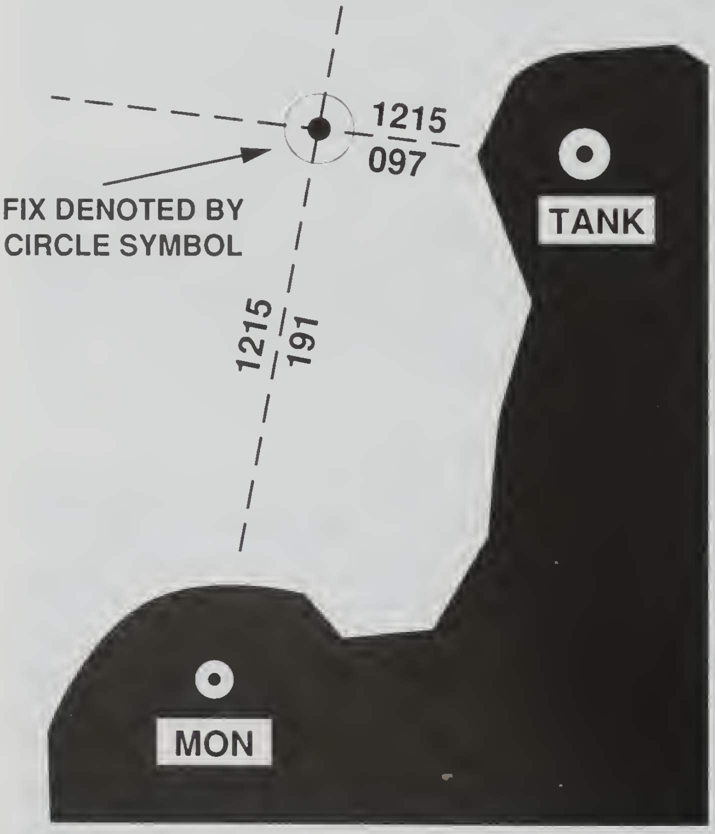


Fig. 7-22. Position by Crossed Bearings on Two Landmarks

You can use the same method to draw the LOP from the monument. Your position is at the point where the two lines cross. This is a fix and is labeled with a dot with a circle around it. Label the LOPs with the time above the bearing lines and the directions below the lines.

When you draw a line of position, do not run it through the mark. Instead, begin *seaward* of the mark and make the line long enough that it passes through your position. At some later time, you may wish to erase the line. If your LOP runs through the mark, you may destroy it when you erase the LOP.

Check Your Work. Make an estimate to check your work. From your original sighting, you knew that the tank was in an easterly direction. It had a bearing of 088°C. That means that you are west of the tank and looking east. East is 090°. The true direction of the tank from your position is 097° which is almost east.

In a similar manner, south is 180°. You observed the monument to be at 176°C. This means you are north of the monument and looking south toward it. The true direction of the monument from your position is 191° which is a southerly direction.

If you had taken bearings on three marks, the three LOPs would, ideally, cross at a single point. In reality, this seldom happens. More often the intersections of the three lines form a small triangle. This is called a cocked hat. The smaller the triangle, the more exact is your position. You assume that you are somewhere within the area of the triangle. Figure 7-23 illustrates a cocked hat.

Taking a visual bearing on a landmark is only one of the many possible ways of getting LOPs. You can learn more about this in our more advanced courses.

Common Conventions

When you write bearings on a line of position or a course line, you write them using three digits as was done above on figure 7-22. In this way, you will not confuse them with units of time or speed. Always write time with four digits using a 24 hour clock. Midnight is 2400, 9:45 a.m. is 0945, and 3:20 p.m. is 1520.

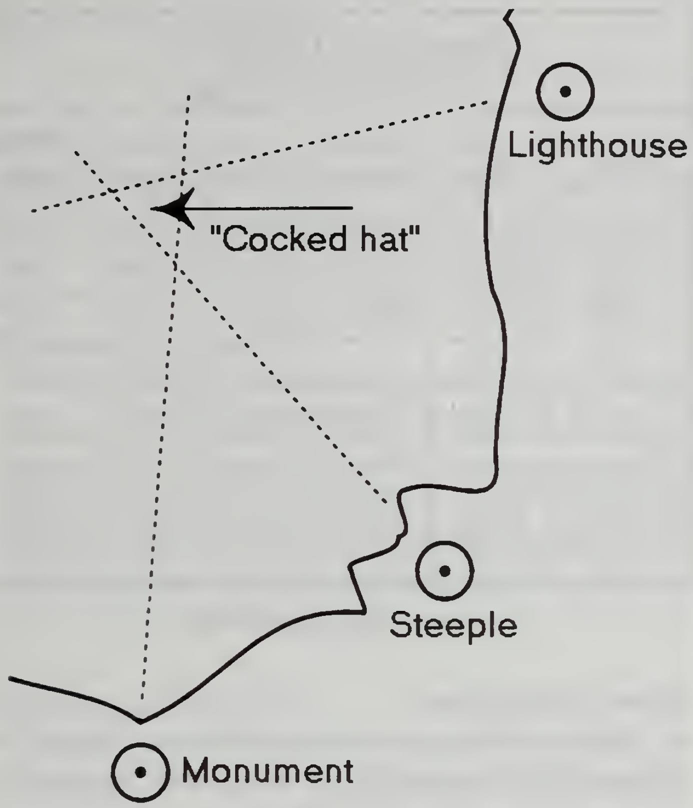


Fig. 7-23. A "Cocked Hat" Formed by Three Lines of Position

Write speed with two digits. Thus, even if you do not identify the measures on an LOP or course line, you know what each is. A four digit number is time, a three digit number is direction, and a two digit number is speed. Use leading zeros where necessary to bring the measures to their two, three, or four digit forms.

SPEED-TIME-DISTANCE

Suppose you plan to make a fishing trip to a distant point. How long will it take you to get there? You need a measure of your boat's speed. You also need to know how far it is to your fishing hole.

Measuring Speed

Measuring a boat's speed is not easy. You can get speedometers for small boats but they are not especially accurate. Furthermore, they give measures of speed through the water and what you need is speed over the bottom. Speed over the bottom may differ from speed through the water because of the effects of wind and current.

If you use a speedometer to determine your speed, part of your problem will be to estimate the effects of wind and current and make allowances for them. If you know how far you are going and how fast you are traveling, you can compute how long it will take you to get there.

Fig. 7-24. Speedometer
(Photo Courtesy of Faria Instruments Division Thomas G. Faria Corporation)

The Speed Table

Most small boats have **TACHOMETERS**. These measure the speed of your boat's motor in revolutions per minute or RPMs. You can construct a **SPEED CURVE** or **SPEED TABLE** to tell you your boat's speed over ground at different engine speeds (fig. 7-25).

To make a speed table, look at your chart. Find two points about a mile apart and measure the distance between them. If you measure the distance in statute miles, your speed table will be in miles per hour or **MPH**. If you use nautical miles, it will be in knots.

Run the course between the two measured points, timing your speed each way with a stopwatch. Run it both ways at the same engine speed to cancel the effects of wind and current. Now, compute your speeds in each direction and average them. *Do not average times to compute the speed.*

Do this for a variety of engine speeds. Average the two vessel speeds at each engine speed. You can use these averages to construct a speed table such as that in figure 7-25.

Computing Time, Speed, or Distance

If you know two of the time-speed-distance variables, you can compute the other one. To do so, use the same formula that most people do. For example, if you travel two hours at 60 statute miles per hour, how far have you gone? You have gone:

$$2 \times 60 = 120 \text{ statute miles}$$

In this formula, time is in hours, speed in statute miles per hour, and distance in statute miles. The formula you used was:

$$\text{Distance} = \text{Speed} \times \text{Time}$$
$$\text{or } D = S \times T$$

Computing Distance

In piloting you use the same formula. However, you measure time in minutes. You measure speed in knots or nautical miles per hour, and distance in nautical miles.

Since time is expressed in minutes, it has been multiplied by 60. So we must do the same to the other side of the equation, thus, the formula becomes:

$$60D = S \times T$$
$$\text{or } D = (S \times T) \div 60 \quad (1)$$

Computing Speed or Time

If you remember your algebra, you can use formula (1), above, to derive two others. If:

$$60D = S \times T$$
$$\text{then } S \times T = 60D$$

Dividing both sides of the equation by S you get:

$$T = 60D \div S \quad (2)$$

If you divide both sides by T you get:

$$S = 60D \div T \quad (3)$$

Formulas (1), (2), and (3) give you means of computing distance, time, or speed. Use formula (3) to build your speed table. If you can remember your algebra, you need only memorize formula (1) to compute speed, time, or distance.

Speed Trial Tabulation
Over Measured Mile

RPM	N - S		S - N		Average Speed
	Time	Speed	Time	Speed	
800	6m 47s	8.85	8m 32s	7.03	7.94
1000	5m 46s	10.41	7m 31s	7.98	9.20
1200	5m 01s	11.96	6m 46s	8.87	10.42
1400	4m 28s	13.43	6m 13s	9.65	11.54
1600	4m 03s	14.82	5m 47s	10.38	12.60
1800	3m 42s	16.22	5m 01s	11.96	14.09
2000	3m 31s	17.06	4m 53s	12.29	14.68
2200	3m 24s	17.64	4m 41s	12.81	15.23

Fig. 7-25. Speed Table

Some Examples

Suppose that you drive your boat at a speed of 20 knots for 12 minutes. How far have you gone?

$$D = (S \times T) \div 60$$
$$\text{or } D = (20 \times 12) \div 60$$
$$D = 240 \div 60$$
$$\text{and } D = 4 \text{ nautical miles}$$

How long does it take to travel 4 nautical miles at a speed of 20 knots?

$$T = 60D \div S$$
$$T = (60 \times 4) \div 20$$
$$T = 240 \div 20$$
$$T = 12 \text{ minutes}$$

How fast are you going if you travel 4 nautical miles in 12 minutes?

$$S = 60D \div T$$
$$S = (60 \times 4) \div 12$$
$$S = 240 \div 12$$
$$S = 20 \text{ knots}$$

An Alternate Method

There is a simple way to use the information in formulas (1), (2), and (3). It is presented in figure 7-26. To use figure 7-26, cover the answer you need. The formula for the answer remains uncovered. For example, if you want to compute speed, cover the S. The formula is 60 × D divided by T. To find time, cover the T. The formula is 60 × D divided by S. To find the distance traveled, cover the 60 × D. You have S and T left. Distance equals S × T. Divide the result by 60.

DEAD RECKONING

Piloting uses **DEAD RECKONING** or **DR** as a method of plotting courses and predicting positions. It is likely that the term was originally "deduced reckoning." This may have been abbreviated "ded reckoning," and later spelled "dead reckoning." Whatever the origin of the term, dead reckoning is used to plot cruises of 30 minutes or more.

A DR plot is a drawing on a chart of the course you intend to follow. Figure 7-27 illustrates a DR plot. It includes notations of directions, intended speed, and dead reckoning positions (DR) at course changes and at 30 minute intervals. Intended speed is written below the line in two digit form.

Drawing a DR Plot

Begin your DR plot at a known position or where you can get a fix. The mouth of a harbor, an inlet, or a fixed aid to navigation is a good place to begin. Mark it on your course line with a dot and a full circle and the intended departure time.

If there are no obstructions between where you begin your plot and where you intend to go, you can draw a straight line between the two. More often, though, there will be obstructions or hazards that will cause you to travel an irregular course. Use your plotting tools to draw your intended course as a series of straight lines between your turning points. If possible, select turning points where there are suitable landmarks or aids to navigation.

After you have drawn the legs of your course line, measure their *true* directions using a course plotter or parallel rulers. Write these directions above the line for each leg using the three-digit form. You can, if you wish, precede each direction with a "C" to mean *course*. If you want to add compass directions to your course plot, follow them with a "C" for compass.

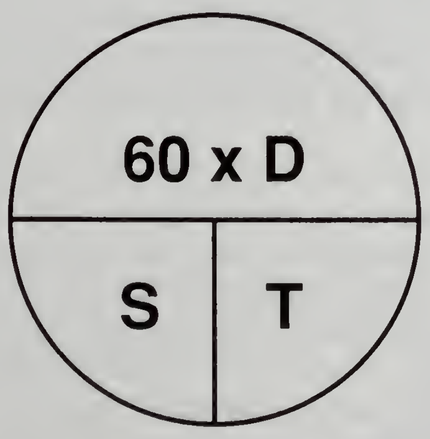


Fig. 7-26. Speed, Time and Distance Relationships

Make your measurements and calculations carefully. In piloting, neatness and accuracy are essential. Small errors tend to be cumulative.

Now, use your dividers and the latitude scale to measure the lengths of the course legs. Use the part of the scale that is nearest to the mid-latitude of each leg. Measure carefully to the nearest one-tenth of a nautical mile.

As you travel over your planned course, you may be able to fix your position. If you find that your DR course is different from your "real" course, make the necessary adjustments to your DR plot.

A Sample Course

In figure 7-27, the course has four legs. The distance in nautical miles from point A to B is 6.6, from B to C it is 9.2, from C to D 13.0, and from D to E 2.4.

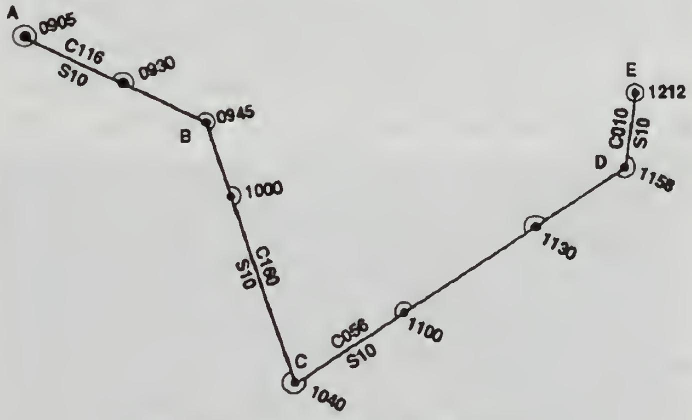


Fig. 7-27. A Typical DR Plot

Labeling a DR Plot

Since you know where you are at point A, you have a fix. You note this by a dot with a circle around it. A dead reckoning position has a dot with a half-circle around it. Each position is marked with the time.

Now, estimate the speed that you intend to use on each leg of your cruise. Write the number below the course line using the two-digit form. You can precede the speeds with an "S" for *speed*. A course line of 116° for a speed of 10 knots would look like

C116
S10

If you desire to add compass direction to the plot, using a variation of 9°W and a deviation of 0°, it would look like this:

C116 C125C
S10

Making Your Computations

Compute the amount of time you will need to get from your departure to your first turning point at your intended speed. Use the formula: $T = 60D \div S$. Remember your time is always in minutes. Round off each time to the nearest minute. Distance is usually in nautical miles and tenths of miles and speed is in knots.

If you are operating on the Great Lakes, rivers, or on other bodies of water where charted distances are in statute miles, speed is in miles per hour (MPH). This is perfectly acceptable as long as you do not mix units. Use statute miles and MPH or nautical miles and knots. Also, if you use statute miles, do not use latitude scales for measuring distances.

As shown in figure 7-27, you expect your speed on each leg to be 10 knots. The computed times for the four legs are, therefore, 39.6, 55.2, 78.0, and 14.4 minutes. Rounded off, they are 40, 55, 78, and 14 minutes.

After you calculate the time that should elapse between your departure and your arrival at the first turning point, add it to your departure time. If you started at point A at 0905, you would expect to arrive at point B 40 minutes later at 0945. This is your estimated time of arrival (ETA) at the point. Since it is a DR position, mark it with a dot and a half-circle. Label this point 0945.

Compute Each Half-hour

If your trip to the first turn includes the start of a new hour or half-hour, calculate your predicted position for that time. Plot it on your course line. Mark it with a dot and a half-circle. In this case you will use the formula:

$$D = (S \times T) \div 60.$$

The question is, “Where will you be at 0930?” Applying the formula you find that you will travel 4.2 miles. Using your dividers, place a dot and a half-circle at a point 4.2 miles from point A. Label this 0930.

Since you are going to show your predicted position each half-hour, you need to know where you will be at 1000. This is 15 minutes after you pass point B. In that 15 minutes you will travel 2.5 miles. Mark this point with a dot and a half circle.

You will arrive at point C at 1040, point D at 1158, and point E at 1212.

PRACTICE YOUR ART

It takes practice to become proficient at piloting. Practice it often. It can “slip” away easily.

No matter how proficient you become, though, practice the “buddy system.” If you move into unfamiliar waters, it is advisable to travel with a companion vessel piloted by someone familiar with the area. Not only will you feel more comfortable, but you will probably have more fun in the process. And that, is what it is all about.

A FURTHER INVITATION

You can learn more about piloting in the Auxiliary's Basic Coastal Navigation and Advanced Coastal Navigation Courses. Ask your instructor when the next ones will be offered.

8

Powering Your Boat

Recreational powerboats have come a long way in the past century. Much of this progress was due to the development of the **INTERNAL COMBUSTION ENGINE**. After its invention, it soon appeared in horseless carriages and in small boats. Recreational boating was off and running.

TYPES OF MARINE ENGINES

You can describe marine internal combustion engines according to: 1. their installation, 2. their operating cycles, and 3. the fuels they use.

Installation Classes

The way a marine engine is installed can be used to classify it. One type of installation is entirely within a boat's hull. In this case, the engine is linked to the boat's propeller by a propeller shaft. Since the engine and the gears that connect it to its propeller shaft and propeller are inside the boat's hull, the engine is an *inboard.*

In a second type of installation, the engine is also in the boat's hull, but it connects to the boat's propeller through a system of gears mounted on the outside of the transom. This is a *stern drive* engine, sometimes called an inboard-outboard or I/O.

A third manner of installation is to attach the motor to the boat's transom or to a bracket attached to the transom. This is an *outboard* motor.

Operating Cycles

The second way to classify marine engines is by their operating cycles. Marine engines are either two or four cycle engines.

An internal combustion gasoline engine works by:

1. drawing in a mixture of fuel and air,
2. compressing it into a smaller volume,
3. igniting it to produce power, and
4. exhausting the spent gasses.

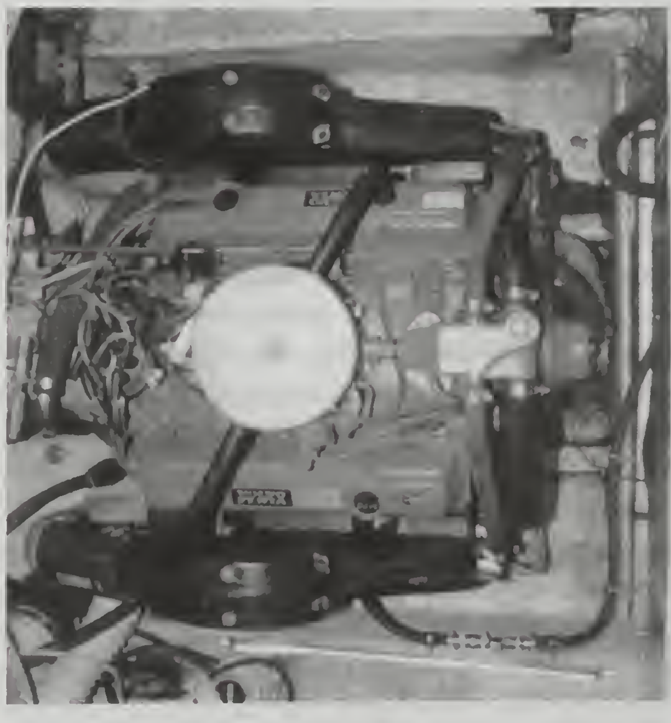


Fig. 8-1. Most Inboard-Mounted Engines Are Automobile Engines Modified for Marine Use.

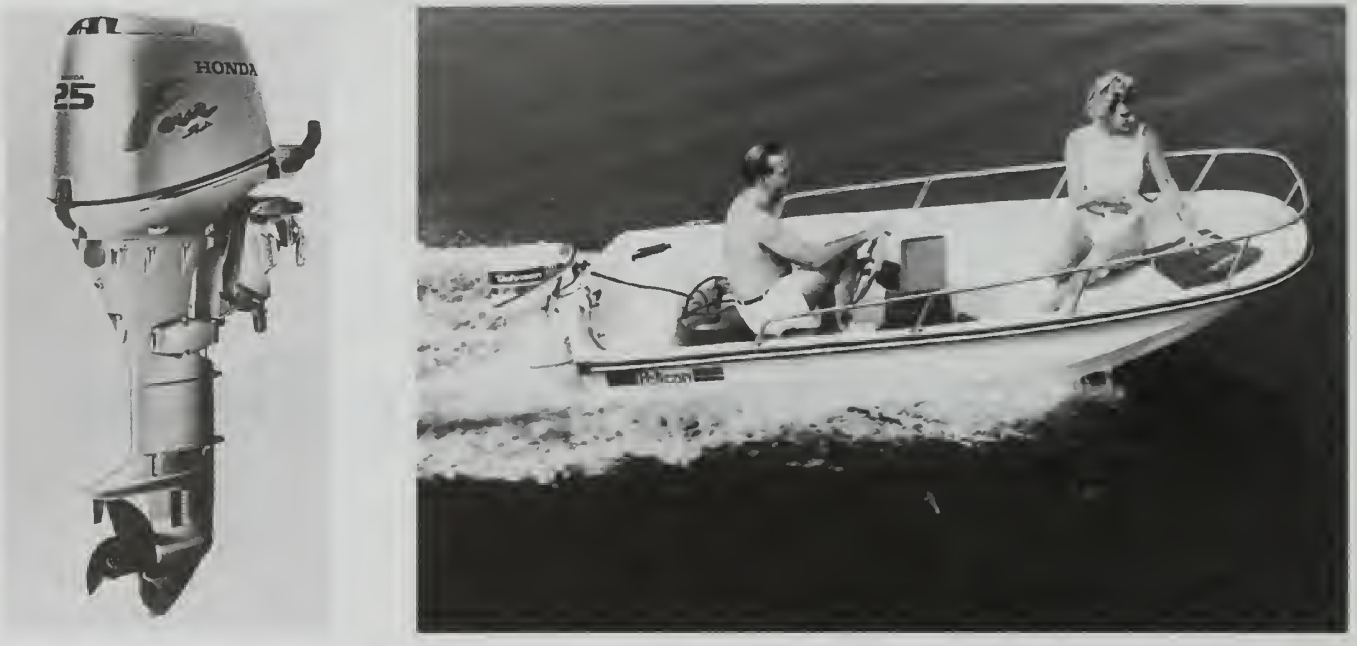


Fig. 8-2. Outboard Motors Are a Popular Form of Power For Small Boats.
(Photo courtesy of Honda Marine and Pelican International Inc.)

Two cycle engines require one revolution of their internal parts to complete these four processes. Four cycle engines require two revolutions. Two and four cycle engines are also called two stroke and four stroke engines.

Inboard and stern drive engines are almost always four stroke engines. Most outboards are two stroke.

Differences in Two and Four Stroke Engines

There are two major differences between engines with two and four stroke cycles. First, for a given power rating, two stroke engines weigh less than four stroke engines. On a small boat this is an important consideration.

The second difference is in the way the engines are lubricated. A four stroke engine has a **CRANKCASE** that holds oil to lubricate moving engine parts. The crankcase of a two stroke gasoline outboard engine does not contain oil. Instead, it is lubricated from oil mixed with the fuel.

Since two stroke engines burn their fuel less efficiently than four stroke engines and since their exhausts contain unburned oil along with unburned fuel, two stroke engines are a greater source of water pollution than are four stroke engines. The least polluting engines are four stroke engines with fuel injection systems. The EPA has announced that beginning in 1998, new engines for recreational boats must emit less smog-causing pollution. Eventually, they plan to cut hydrocarbon emissions by as much as 75%.

Until recent years, it was necessary to add oil to the fuel in a two stroke outboard engine's fuel tank or to buy pre-mixed fuel. It is now possible to buy two stroke engines that do this job for you. These engines have special reservoirs for storing oil. The oil is mixed with the fuel before it enters the engine or it is injected into the fuel when the fuel is injected into the engine. Motors with **VARIABLE RATIO OILERS** (VRO) vary the amount of oil mixed with the fuel according to the speed at which the engines are operating.

Be sure that you use the proper oil in your two stroke engine. Engine oil will not suffice. Instead you need an oil made especially for mixing with your fuel. There are separate types for air and water cooled engines. Look at the label on the container. It should say, "TC-W" if, for example, it is for two cycle, water cooled engines.

Classification by Type of Fuel

The third classification of marine engines is by the type of fuel they use. Both two and four stroke gasoline or diesel-powered engines are available. Diesel engines operate more efficiently than gasoline engines. They get more energy from the same amount of fuel. Thus, diesel engines are less expensive to operate.

Diesel engines have fewer moving parts than gasoline engines. This means greater reliability and fewer maintenance problems. Diesel engines enjoy a reputation for long term reliability.

Diesel engines have some drawbacks. Because of the way they work, they must be larger and heavier than gasoline engines. As a result, they are also more expensive. Over time, though, their higher initial cost is offset somewhat by savings in fuel and maintenance costs.

Also because of the way they operate, diesel engines vibrate more than gasoline engines. They are also noisier. The vibrations tend to loosen bolts so crankcase and gear case attachments must be checked and tightened periodically.

Risks from Fuel

Diesel engines have a reputation for being safer than gasoline engines. Gasoline is very volatile, that is, it gives off fumes very easily. Furthermore, these fumes are highly flammable. In a confined area, they are explosive.

Diesel fuel does not volatilize as readily as gasoline, and its fumes have a higher flash point. This means that it takes a hotter spark to ignite diesel fuel than it does to ignite gasoline. Thus, diesel fuel is safer than gasoline.

However, diesel fuel is not entirely free from risk. Any fuel line can rupture and spew its contents onto a hot exhaust manifold thereby igniting the fuel. If diesel fuel leaks into the bilge, any fire in the bilge will use it as a fuel.

Diesel fuel is subject to problems. First, because it is injected into engines, it must be very clean and free of water. To ensure this, the engine must have additional filters, and these must be changed frequently. A second disadvantage is that diesel fuel gels at very cold temperatures. To prevent this, you must add an inhibitor in cold weather. Third, fungus can form in diesel fuel. When present, it clogs fuel injectors. A special antimicrobial agent must be added regularly to prevent fungus formation.

MARINE ENGINES

Inboards, stern drives, and outboards get their names from the way they are installed in or on boats.

Inboard Engines

An inboard engine is installed amidships. It usually faces forward as in an automobile with rear wheel drive. It is connected to a propeller shaft by a clutch and a system of gears. The clutch serves to disengage the crank and propeller shafts so the engine can run without the boat moving. It also enables the boat to go forward or to reverse. This type of inboard installation is a **DIRECT DRIVE INBOARD**. The engine, clutch, and gears are located in the boat's hull.

In some instances the inboard engine faces aft, and its crankshaft is connected to a gear box. Its propeller shaft connects to the box. This form of installation is a **V-DRIVE INBOARD**.

Direct Drive vs. V-Drive

Propellers are most efficient when their thrust is parallel to the water's surface. When the thrust is at an angle, part of it is wasted in lifting the boat's stern. The farther forward a direct drive engine is mounted in a boat, the closer its thrust comes to being parallel to the water's surface. But there is a practical limit to how far forward you can mount an engine. If you move the engine forward, the result may be an inconvenient arrangement of the available

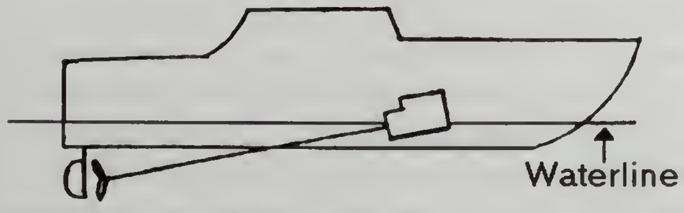


Fig. 8-3. A Direct Drive Inboard Engine Installation

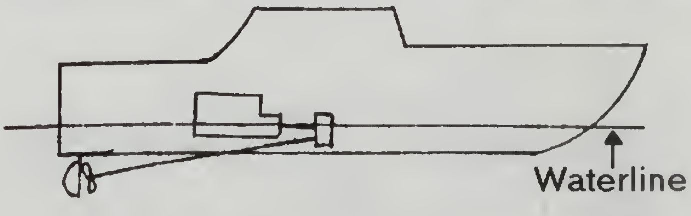


Fig. 8-4. A V-Drive Inboard Engine Installation

space within the boat.

Even with this draw-back, a direct drive engine has advantages over a V-drive. It is the simplest, least expensive, and most trouble free of all inboard engine installations.

A V-drive engine (see fig. 8-4) is installed farther aft than a direct drive engine. Because of the gear box, a relatively small angle between the propeller's thrust line and the water's surface can be achieved. The gearbox, however, increases weight and decreases efficiency. It also adds another lubrication and cooling problem.

Tunnel Drives

A tunnel drive is a variant of a direct drive. The tunnel is a trough in the bottom of the boat, extending forward from the stern. With it, the thrust line can be more nearly parallel to the water's surface. Besides providing a more favorable thrust angle, the tunnel acts as a shroud around the propeller.

Stern Drive Engines

A stern drive engine is mounted inside a boat, near its stern. The unit consists of an engine and an outdrive, sometimes called the lower unit. The outdrive is a system of gears mounted outside the boat on the transom.

Stern drive units are considerably more expensive than direct or V-drives. Their maintenance and repair are also costly. Their gears are complex and easily damaged.

Outboard Motors

The third type of installation is an outboard motor. The motor fastens to a boat's transom or to a bracket fastened to the transom. It consists of a power generating mechanism (the powerhead), a clutch, a gear box, and a propeller, all in one unit. It may or may not have a tank for storing oil to be mixed with the gasoline if it is a gasoline powered outboard. Some small outboards have built-in fuel tanks.

Some small outboards do not have clutches and reverse gears. To reverse direction, you turn the motors around so their propellers face forward.

Small outboards have pull starters. Larger ones have electrically operated starter motors and alternators. Outboards with starter motors require batteries.

Stern Drives or Outboards

Which is better, an outboard or a stern drive? A definitive answer can't be given, but there are important differences in the two engines.

Outboards weigh less than comparably sized stern drives. A 150 horsepower (hp) outboard weighs about 300-400 pounds. An equivalent stern drive weighs twice as much. On a small, light boat this difference is important. It is less important on a heavier, larger boat.

On the other hand, stern drives use fuel more efficiently. A stern drive will use 15 to 30 percent less fuel than an outboard of comparable size. The difference may be even greater at displacement and trolling speeds.

A stern drive requires six or more square feet of deck space. An outboard takes up no space within the boat. In addition, when the outboard is on a bracket, the boat can have a full transom. This gives it freeboard equal to that of a stern drive equipped boat.

Stern drives, because they are in hooded bilge compartments, are usually quieter than outboards. When the outboard is on a bracket and the boat has a solid transom, however, the outboard may be the quieter engine.

An important consideration for some owners is that outboard engines and their electrical parts are outside the boat. This reduces somewhat the danger of fire and explosion.

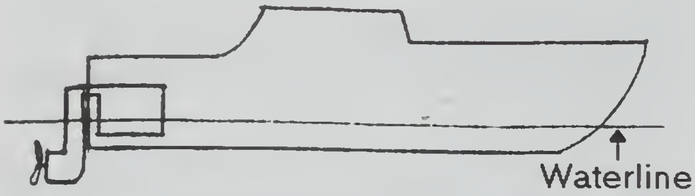


Fig. 8-5. A Stern Drive Engine Installation

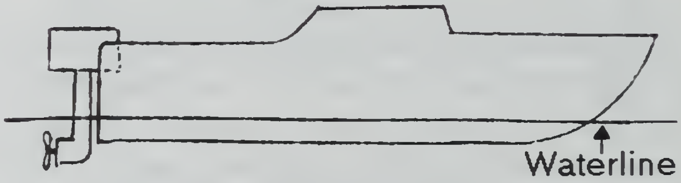


Fig. 8-6. An Outboard Motor Installation

One other point. Boats usually outlast their motors. Outboard motors are easier to replace and usually cost less than stern drive engines. The cost of servicing outboards is usually less than for stern drives. If the outboard is small, it can be dismounted and taken to the repair facility.

Engine Sizes

Reference to kilowatts is no longer just to electricity. The International Congress of Marine Industry Associations (ICOMIA) has changed the method and units for measuring engine power. This makes it easier for boaters to compare engines.

In the past, an engine's power was measured at its crankshaft. This method did not consider loss of power due to the engine's gear train. As a result, the ratings were usually too high.

As of September 1, 1989, all measures of engine power are made at their propeller shafts except for inboard engines sold without transmissions. This results in lower ratings for marine engines. For outboards, the reduction is about 5 to 10 percent. Because of their extra gears, the reduction for stern drives is about 10 to 15 percent. Inboard engines with hydraulic transmissions are lowered about 15 to 20 percent.

In addition, the ICOMIA changed the unit for rating engine power. Previously, the unit was horsepower (hp). The standard is now the kilowatt (kw). A kilowatt is the equivalent of 1.34 horsepower. If you want to know how many kilowatts of power your 150 horsepower engine develops, divide the 150 by 1.34. It has about 112 kilowatts of power. To change from kilowatts to horsepower, multiply kilowatts by 1.34.

A Special Warning!

All inboard and stern drive engines look like automobile engines. Most use automobile engine blocks. Beyond this point there are important differences between automobile and marine engines. Most marine engines use special devices for discharging exhaust fumes and cooling water. All marine fuel pumps, alternators, starters, distributors, and other electrical parts are designed specifically to prevent sparks or the release of fumes.

Much of this special marine equipment is necessary since, unlike automobile engines, inboards and stern drives operate in enclosed spaces which are ventilated. Gasoline fumes can collect in these spaces, and equipment that can produce sparks may produce disastrous results. *Never repair a marine engine with automobile parts. The result may be a fire or an explosion.*

SELECTING A PROPELLER

Matching your boat and engine with the right sized propeller can make a big difference in performance. For most recreational boats it is a simple process. Make the following test with a clean hull.

You need to know, first, how fast your engine ***should*** operate with wide open throttle (WOT). You can find this information in your owner's manual. If not, your dealer can give it to you. Outboards generally have WOT ranges of 5,000 to 6,000 revolutions per minute (rpm). Stern drives usually range from 4,200 to 4,600 rpm.

You next need to know how fast your engine runs at WOT. Before you make the test, check to see that your propeller is neither dinged, nor bent. Now, take your boat out on the water with a normal load and weight distribution and adjust the trim as you usually do. Run it with WOT. If you have a reliable tachometer, it will tell you how fast your engine is running.

When your engine is running too slow, replace your propeller with one with less pitch. When it runs too fast, choose one with greater pitch. In general, one inch of pitch is equal to 200 rpms. So if your engine is running, for example, 400 rpms too slow at WOT, reduce the pitch of your propeller by two inches. Some dealers will let you try out propellers and re-

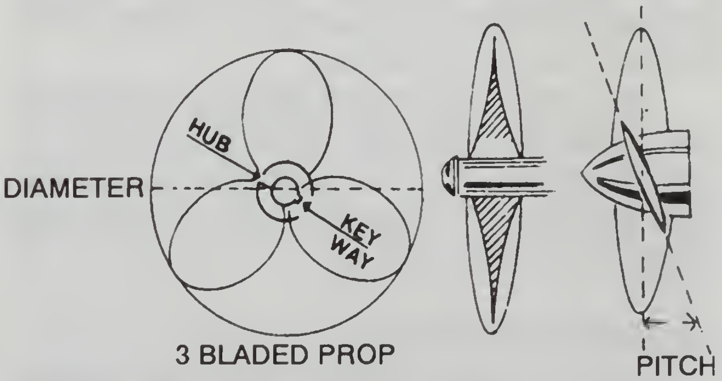


Fig. 8-7. A Three-Bladed Propeller

turn them if you have not dented, bent, or scratched them. Keep trying different propellers until you have one that matches your boat and engine.

INDUCTION SYSTEMS

The induction system of a gasoline powered internal combustion engine brings fuel and air together. It then mixes them in the proper proportion, vaporizes the mixture, and delivers it to the engine. The most critical part of the system is the mixing and vaporizing. Carburetors or fuel injection systems serve this purpose.

Carburetors

Carburetors are complex mechanisms. Modern carburetors operate in as many as four separate modes: idling, accelerating, normal cruise, and sustained high speed. They also operate smoothly through a wide range of engine and air temperatures.

Because of the demands placed on them, carburetors have become highly complex. It is best to leave their adjustment or overhaul to specialists.

Many outboard motors now have two or more carburetors. This increases their reliability. It also increases their complexity.

Fuel Injection

Fuel injection systems are replacing carburetors. They are a good response to the complex, critical, and expensive devices that carburetors have become.

Gasoline fuel injection systems use small computers ("little black boxes"). These computers receive information from sensors that determine things such as fuel demand, throttle position, and engine temperature. Some computers also consider air temperature, barometric pressure, amount of carbon monoxide in the exhaust, and other factors.

The computers control the flow of fuel into units that mix it with air and vaporize the mixture before it is fed into the engine. The usefulness of fuel injection in marine gasoline engines has been shown.

IGNITION SYSTEMS

After the fuel mixture enters an engine, there must be some means for igniting it. The burning fuel mixture provides the energy that powers the engine.

Diesel Fuel Ignition

Diesel engines do not have ignition systems. Air is drawn into the engine. It is then highly compressed. This heats it to a high temperature. When the fuel is injected into the engine, the hot air immediately ignites it. This powers the engine.

Gasoline Engine Ignition

The compression of the fuel-air mixture in a gasoline engine does not produce enough heat to ignite the fuel. So, another means is used. An electric current is generated and passed through a spark plug. This produces a spark that ignites the gasoline-air mixture. The electrical current comes from one of three different sources.

Magneto Ignition

Small, two stroke outboard motors have magnetos that are high voltage generators. They are built into the flywheels of the motors. When you pull the starter cord on this kind of motor, permanent magnets rotate and cause an electric current to be generated. This current is sent to the spark plugs at appropriate times. The spark ignites the fuel and powers the motor.

All motors with magnetos have breaker points and a condenser. These points must be adjusted correctly to operate efficiently. If the condenser fails, electricity is not delivered to the motor and it will not run.

If the condenser fails partially, the motor will start and run at fairly high speeds in neutral. In gear, it will not run much above idle speed. Have the points and condenser inspected and replaced every two or three years. You probably can't do this job yourself since you must have special tools to remove the flywheel. Never replace breaker points without replacing the condenser.

Alternator-Battery Ignition

Some larger two stroke gasoline engines and all four stroke gasoline engines use a second method to create a spark to ignite the fuel.

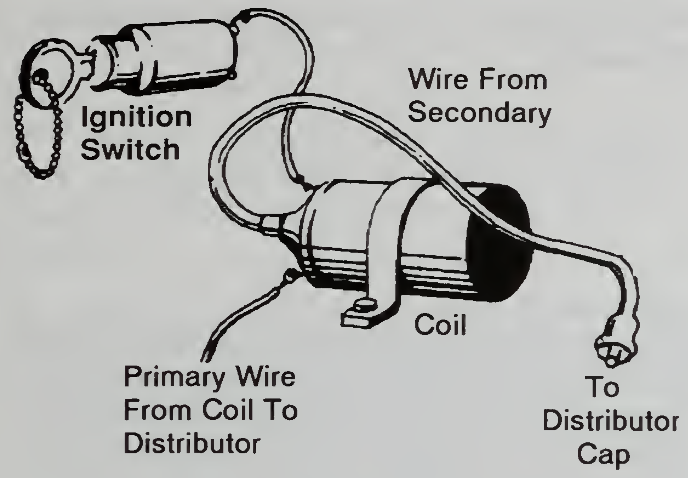


Fig. 8-8. An Ignition Switch and Coil

As in an automobile, the engine drives an alternator that creates an electrical current. This current is stored in a battery. An ignition coil transforms the 12 volt current of the battery to the high voltage needed for igniting the fuel. Some outboards have an ignition coil on each cylinder. This increases the motor's reliability. If one or more coils should fail, it is still possible to operate the motor.

An engine with battery-alternator ignition has breaker points, a condenser, a distributor, and an ignition coil. These deliver current to the spark plugs at the appropriate times. Inspect the points and condenser and replace them periodically. Also, inspect the distributor and its cap for cracks.

Electronic Ignition

There is a third, and newer, method of igniting the fuel in an engine. It is called an electronic ignition system and is used on all types of gasoline engines. It uses solid state switching sometimes called a "black box." This box replaces distributors, condensers, and points. These are the least reliable parts of older ignition systems. They are also the parts that require the most maintenance.

An electronic ignition system delivers a much hotter ignition spark for a shorter duration than either of the other systems. This makes starting easier since it provides greater precision in timing the delivery of the electrical current to the engine.

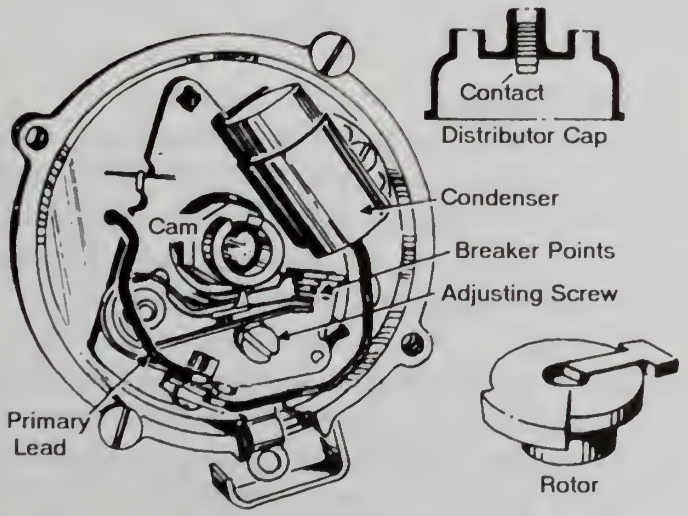


Fig 8-9. A Distributor, Cap, and Rotor Showing Breaker Points and Condenser.

FLAME ARRESTERS

Sometimes when the fuel ignites, a backfire occurs. This is an explosion through the air intake of the carburetor. It can cause a fire or an explosion. Because of this, inboard and stern drive engines must have flame arresters. Keep your flame arrester clean. Detergents are available for this purpose.

Outboard engines do not require flame arresters since they do not operate in enclosed spaces.

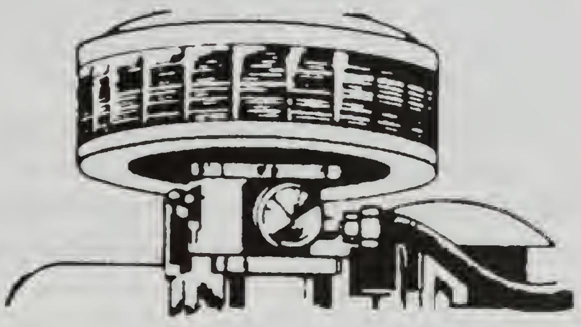


Fig 8-10. A Flame Arrester Can Prevent An Accidental Explosion.

COOLING SYSTEMS

The fuel that burns inside an internal combustion engine produces large amounts of heat. Some way to cool the engine is essential.

Air Cooled Engines

Some very small outboard motors are air cooled. To do this, air is blown over them. Larger outboards, stern drives, and inboards produce too much heat to be cooled this way. Furthermore, stern drives and inboards are enclosed in compartments where there is insufficient air with which to cool them. Some other method of cooling them is necessary.

Water Cooled Engines

Most marine engines are water cooled. There are two ways in which this is done.

Open Cooling Systems

Internal combustion engines contain water channels through which water circulates. Water is pumped into the engine from outside the boat. It circulates through the channels, and is then dumped overboard. This is an open circulation system.

Your engine's water intake may become clogged by weeds, trash, or other debris. If it overheats, examine the intake and clear it if necessary. Do not operate your engine if it is overheating. Severe damage may result.

The engine's cooling system usually has a thermostat. This blocks the flow of water through the engine until it warms up. When the engine is warm, the thermostat opens and allows the cooling water to circulate. When a thermostat is faulty and stays open all the time, the engine will warm up slowly. If it fails to open, the engine will overheat. In either case, you should replace the thermostat.

In most marine engines, an impeller spins and pumps the water. An impeller is a propeller-like device made of rubber or neoprene. It is turned rapidly by the engine.

An impeller has a relatively short life. Its life is even shorter if you run your engine without cooling water. If you run it when the boat is out of the water, supply water to it through a hose and an adapter.

Dual Cooling Systems

Some inboards and stern drives have dual cooling systems. In these systems, the engines are designed to have a mixture of water and antifreeze. This mixture is circulated by a pump like that on an automobile engine. As the water circulates, it passes over a heat exchanger that cools it. This is a closed circulation system.

The heat exchanger serves the same purpose as an automobile radiator. However, the exchanger is cooled by water and not by air as in an automobile. Water is pumped into the cooling system, circulated around the exchanger, and discharged out of the boat. This is called an open circulation system. In a dual cooling system, only the closed system has a thermostat.

Cooling System Precautions

Modern marine engines can operate in either fresh or salt water without harm if cared for properly. Normally, you do not need to flush your engine with fresh water. However, engines having iron or steel blocks and open cooling systems should be flushed after each use in salt water. If you have operated your engine in polluted or brackish water, you may wish to flush it.

Flushing is also helpful in reducing the spread of zebra mussels from one body of fresh water to another (see chapter 3). Use a garden hose and a special adapter. If you are taking your boat from one fresh water lake or river to another, flush your engine and take the other precautions recommended earlier.

Consult your owner's manual for operation and care in freezing weather. Usually, in freezing weather you should keep your outdrive or the lower unit of your outboard submerged in the water. This prevents its freezing and possible damage unless the water around the unit freezes. If you take your boat out of the water in freezing weather, keep its lower unit in its operating position (down position) until all water has drained from it.

GASOLINE CONSIDERATIONS

Changes in the lead content of gasoline in recent years have had serious implications for boaters. The removal of lead has resulted in lower octane ratings and, in some cases, the addition of alcohol to gasoline.

Leaded Gasoline

For many years, gasoline had lead in it. The lead served two purposes. First, it lubricated and protected exhaust valve seats in four cycle engines. Second, even a small amount of lead raised the **OCTANE** rating of the gasoline.

An octane rating is a measure of a fuel's resistance to premature detonation, that is, detonation before ignition. Premature detonation causes knocking or pinging in engines. It results in power loss and damage to engine parts. It can destroy an engine in a few hours.

Most four cycle engines manufactured since 1974 have induction hardened valve seats. They do not need lead for lubrication under normal conditions of operation. If your inboard or stern drive engine is a 1973 or earlier model, you should probably add a lead substitute to your gasoline.

You do not need to add lead to the gasoline in your two cycle outboard motor. It does not have valves that require lubrication by lead.

Octane Ratings

Prior to 1986, "regular leaded" gasoline had an octane rating (AKI or antiknock index) of 89. In 1986 the Environmental Protection Agency reduced the lead content of gasoline. Some regular grade gasolines then had octane ratings of 87. In 1989, EPA removed all of the lead. This resulted in regular grade gasoline with an octane rating as low as 86. Premium, unleaded gasoline continued to have octane ratings of 91-93.

To compensate for the lower octane ratings in lead-free gasoline, oil companies increased the amount of octane boosting additives in their gasoline. Unfortunately, these additives cause carbon build-up in two cycle outboards and other marine engines subject to hard use. The carbon causes engine wear to increase and performance to drop. In severe cases, engines "freeze" up completely.

You can reduce engine deposits by using quality gasoline, which contains a detergent that combats carbon build-up. Each of the major oil companies uses a different trade name for its detergents, but all of their gasolines contain them. You can purchase detergent additives to add to your gasoline if it does not already contain them.

Consult your owner's manual or your dealer to see the octane rating your engine needs. If your outboard motor is a 1985 or earlier model, consult your dealer to see what adjustments to make for it to use lower grades of gasoline. One tankful of 86 or 87 octane gasoline in a pre-1986 outboard motor can do irreparable damage if the motor has not been properly modified.

Premium Gasolines

One way to avoid the problem of premature detonation in pre-1986 outboards is to use "premium unleaded" gasoline. This is expensive and it may be wasteful. It may be cheaper to have the engine modified.

Any gasoline that eliminates premature detonation develops all the horsepower you can get from your motor. If you use more "powerful" gasoline than your engine needs, you do not get more power. The alternative to using 91-93 octane gasoline in a pre-1986 outboard, though, could be costly engine repairs. For 1986 or later models of outboards, there probably is no problem. Consult your owner's manual to see what grade of gasoline you should use.

Alcohol and Gasoline

During the oil shortage of the 1970s, some oil companies began to add alcohol to gasoline. This extended the supply of gasoline and boosted its octane rating. Since alcohol was cheaper than gasoline, it also lowered the price.

Also in the 1970s, automakers began to use emission control systems that could not tolerate lead. Since the 1974 model year, most U.S. automobiles run on lead-free gasoline. In some cases, though, they require a higher octane gas. To produce the higher octane, some oil companies added alcohol to their gasoline.

Some service stations still sell alcohol-blended gasoline, but few marinas do. The alcohol is usually ethanol but is sometimes methanol. Many states require pumps that dispense gasoline containing alcohol to have labels on them to inform customers. *Some states do not have this requirement.* Where required, dealers must state at a minimum that the gasoline contains alcohol and the kind it contains. Gasoline with ethanol is sometimes called gasohol.

There are at least three important things to consider if you use gasohol in a marine engine.

Alcohol and Outboards

First, alcohol raises the octane rating of gasoline but all outboard motors do not respond to it in the same way. If you use gasohol in your outboard, it should probably have an octane rating of at least 91 to avoid damage.

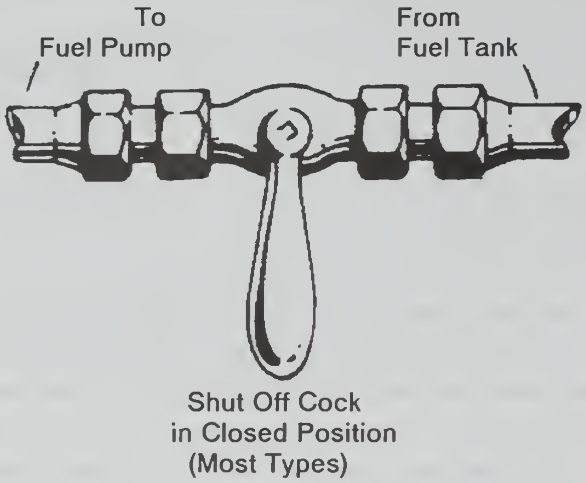


Fig. 8-11. Fuel Shut-off Valve

Alcohol and Fuel Systems

A second consideration in using gasohol is its effects on fuel lines and variable ratio oilers (VRO).

Either methanol or ethanol blended gasoline may adversely affect your engine's fuel system. The effects of methanol are greater than those of ethanol.

Fuel Lines. Automobiles have metallic fuel lines. Thus, gasohol does not affect them. On the other hand, because of vibration, marine fuel lines are usually flexible or have flexible sections. All flexible fuel lines are permeable to gasoline to some extent. Gasohol permeates a flexible line two to four times faster than gasoline without alcohol.

Even hoses that look good can be permeable to gasoline at a dangerously high rate. In severe cases, they may bleed enough to form droplets of gasoline on the hose. If you cannot see gasoline on your fuel line, wipe it clean and check it in a few minutes. Blot the hose with a clean paper towel. Is it wet? If so, replace it.

Examine your fuel line. Replace it if it is hard and brittle or cracked. Neither should it feel soft nor mushy when you squeeze it. If it does, replace it. Use the newer SAE J1527 hose. It is less permeable.

If you replace your gas line, you probably should also change the fill and vent hoses on your fuel tank. Alcohol can affect them, too. If you fill your tank completely, some gasoline remains in contact with these hoses. It may weaken them.

Gasohol may also adversely affect an outboard's variable ratio oiler (VRO). Those made before 1986 had rubber parts that swell in the presence of alcohol. This causes pump failure. Those made in 1986 and later do not contain such parts.

If your permanently installed tank does not have a fuel shut-off valve, install one. If you use portable tanks, the quick disconnect serves as a fuel shut-off. Also, if you do not have a water separator filter in your fuel line, consider installing one.

Fuel Tanks

There is a third consideration in the use of gasoline with alcohol—its possible effect on your fuel tank. Alcohol has a strong affinity for water. Sometimes, alcohol dissolved in gasoline will come out of solution and combine with water. Because boat fuel systems are open to the atmosphere, moist air can condense inside the fuel tank and leave water in the tank. One way to reduce condensation is to keep your fuel tank full at all times.

An alcohol-water mixture inside a fuel tank can corrode it. The tank can then leak and become dangerous. Inspect your tank at least annually. Replace it if there is any sign of corrosion or leakage. If you replace it with a plastic one, be certain it is a "permanent" type and that it has a label showing that it meets Coast Guard requirements. Such tanks have limited permeability, that is, they do not "sweat" gasoline excessively.

BATTERIES

Unless your outboard engine starts with a pull starter, you must have a battery. Your battery is one of the most important items on your boat. Without it you can't start your engine, call for help, display your lights, or pump your bilge if your only pump is electric. Since it is so important, many boaters have a second, back-up battery. A back-up battery is useless, though, if the batteries are not electrically isolated from each other. Should a fault develop in one battery, any other battery connected to it will also lose its charge.

Marine engines usually use "deep-cycle" batteries. Unlike automobile batteries, such batteries can be completely discharged and then recharged more often than automobile batteries. Alternate discharging and charging an automobile battery damages it. Deep-cycle batteries are especially useful for powering trolling motors.

Battery Switches

With a battery isolation switch you can use either of two batteries or both at the same time. Some of these switches should be operated only when the engine is stopped and the ignition switch turned off. You can switch some, though, from battery "1" to battery "2" or to "both" while the engine is running. Determine which kind you have before you switch batteries. Failure to do so may damage your alternator.

Check Your Battery

If your batteries are not "maintenance free," check their fluid levels every month or two. If they are low, add distilled water. When it is necessary to charge a "dead" battery, you will probably need to add water. During the charging, some water breaks down into hydrogen and oxygen. These gases usually escape into the atmosphere. In a confined space, the hydrogen is highly explosive. Keep sparks away from it.

Checking Your Battery's Charge

You can check a battery's charge with a hydrometer. Water has a specific gravity of 1.0. A fully charged battery has a specific gravity of 1.270 or more. A discharged battery has a specific gravity of 1.150 or less.

If your boat has a voltmeter, you have a continuous check on your battery's condition. When you turn your ignition switch on, a fully charged battery should register about 12.5 volts. If it registers 11 volts or less, it has lost its charge. If your battery is in good condition, your voltmeter will show a reading of about 13.5 to 14.0 volts when the engine is running.

Ammeters do not give the same information as voltmeters. An ammeter shows the rate at which the alternator is delivering current to the battery when the engine is running. Its charging rate depends on the condition of the battery. If the battery is low or fails to hold a charge, the ammeter will show a high delivery rate. As the battery charges up, the delivery rate will drop back and may be as little as zero. If the ammeter shows "discharge" when the engine is running, something is wrong with the alternator. If your alternator has a drive belt, it may be broken. Otherwise, the problem may be with the alternator itself.

Battery Failure

Sometimes even with fully charged batteries the starter will not engage and crank your engine. This usually results from loose or corroded battery terminals. If your starter will not operate, check the battery terminals. Sometimes you need only to tighten their clamps to correct the problem. You may need to clean the terminals and clamps. A special brush is available for this purpose. If you remove the clamps from their terminals, remove the positive one first, and then the negative one. The positive terminal is the one marked with a + or is colored red. When you return the clamps to the posts, do it in the reverse order. This prevents sparking.

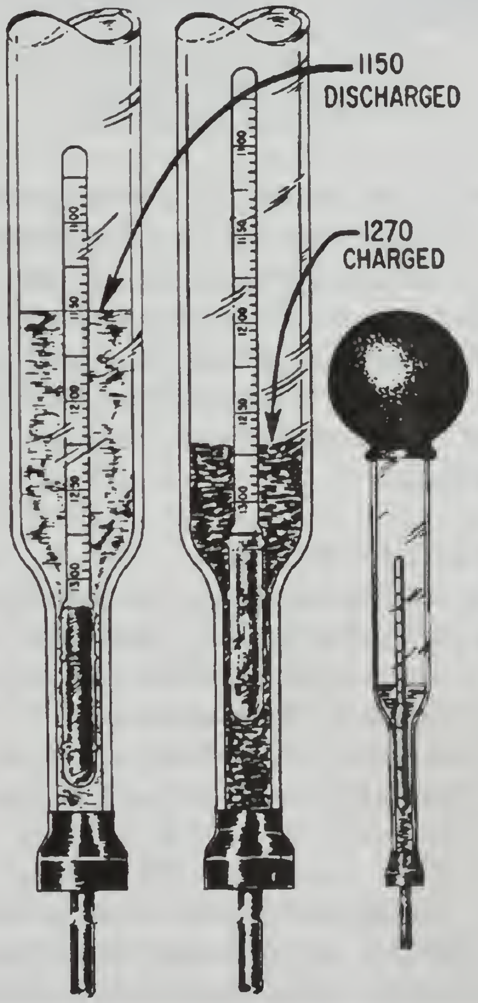


Fig 8-12. Test the Condition of Each Cell of the Battery With a Hydrometer Regularly.
("Basic Electricity" U.S. Navy [NAVPERS 10086.B] Bureau of Naval Personnel)

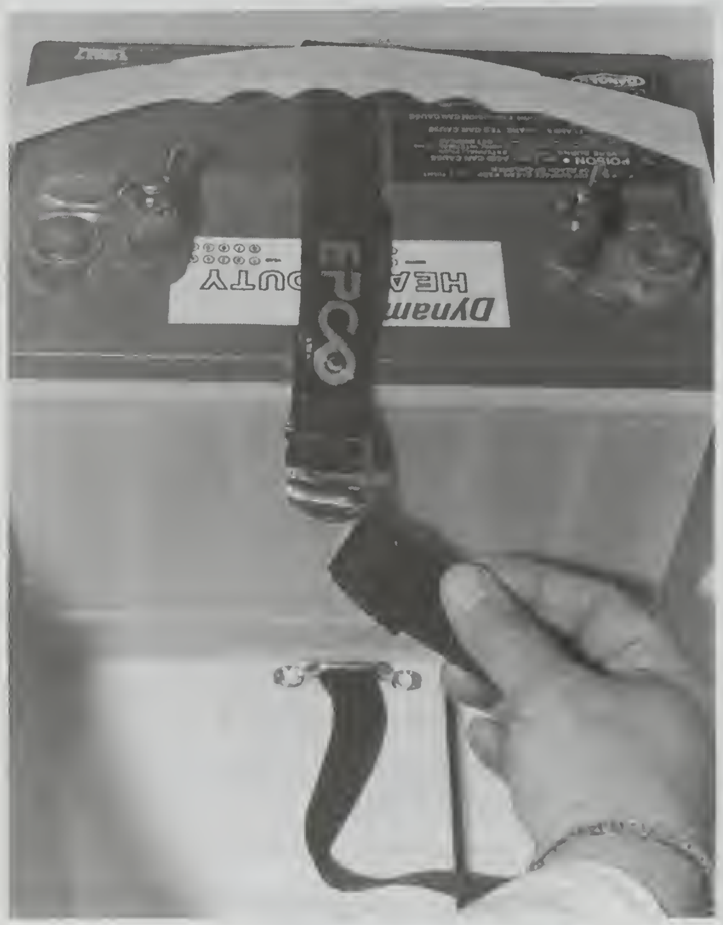


Fig. 8-13. Rugged Battery Strap is Essential Equipment.
(Photo courtesy EPCO)

Crank the engine for a few seconds. Now feel the terminals. If they are more than slightly warm, you have poor or dirty connections.

If your battery cables are worn or if they get hot when you are starting your engine, replace them. They are doing a poor job of delivering current from your battery. They may also be a fire hazard.

Corroded Terminals

The easiest way to approach the problem of corrosion on your battery terminals is to prevent it. Coat the terminals and their clamps with petroleum jelly or grease.

If you haven't coated the terminals, you will get corrosion. To remove it, make a solution of two tablespoons of baking soda in a pint of water. Turn the battery switch to "off" and slowly pour the solution over the battery terminals. Don't let any of it enter the battery. It will fizz as carbon dioxide is released. If necessary, scrub the terminals with a brush. Continue the treatment until the fizzing stops. Now, coat the terminals!

Some batteries have side mounted terminals with wing nut connectors. Side mounts are not subject to as much corrosion as top mounted terminals. Even so, you may need to clean them if you haven't coated them.

Secure Your Battery

Keep your batteries in secured and vented plastic containers with covers. If they are not in secured containers, they may tip over or tear loose in rough water.

Batteries not in covered containers may accidentally be short circuited. This happens if you drop a tool or some other metal object and it touches both terminals. A shorted-out battery makes a large spark. This can cause a fire or an explosion. It is also hard on the battery and will shorten its life.

A short circuited battery heats rapidly. It can become hot enough to boil its fluid and explode. This can also happen if you use your starter excessively. Protect yourself and your boat--put the battery in a vented, plastic container and secure the container.

Use Both Batteries

Batteries last longer and perform better when you use them. If you have two batteries, don't use them both at the same time. Also, don't use the same battery all the time. Switch from one to the other regularly.

If you plan a trip and will anchor all night, use only one battery for your anchor light. This leaves the other battery for starting your engine the next morning.

Short Circuits

Batteries may be "shorted out" by anything metallic such as tools or the jewelry you are wearing. Jewelry can also cause short circuits at electrical junction points such as a fuse panel, the solenoid on the starter, or any bare wire. Don't wear necklaces, rings, bracelets, metal watch bands, etc. when you are working near your battery or any of the electrical connections aboard your boat, and be careful with all tools.

Although the electrical systems on most small, recreational boats are 12 volts, short circuits can deliver dangerous amounts of energy for brief periods. This energy can cause personal injury and can pose a fire hazard. The metal causing the short-circuit can be melted instantly. Having your wedding ring, for example, vaporized while it is still on your finger would be painful and cause permanent injury.

The possibility of a short circuit is another strong argument for a battery isolation switch. The energy present in a short circuit can quickly melt the insulation on a wire and may ignite it or anything in contact with it. Electrical failures of this kind are the leading cause of fires aboard boats. It may be impossible to extinguish an electrically caused fire unless the batteries are disconnected. If the fire is extinguished and the batteries are not disconnected, the fire may be rekindled.

The easiest way to disconnect batteries is a battery isolation switch. If this switch is used to disconnect the batteries from the electrical system of your boat when it is not in use, an electrically caused fire is almost impossible. If you leave your boat on the water and turn off the disconnect switch, be certain that your bilge pump is wired directly to the battery so it can operate independently of the switch.

Charging Your Batteries

The first step in charging your battery is to turn your battery isolation switch to the "off" position. This reduces the possibility of an electrical spark being produced near the hydrogen and oxygen which are generated during the charging. Also, be careful to see that the area containing the battery is well-ventilated so as to disperse the hydrogen and oxygen.

Unless your battery is a "no maintenance" battery, before charging it, remove the caps which cover the battery's cells to allow generated gasses to escape. Check to see that the battery's plates are covered with fluid. If necessary, add distilled water, but do not overfill. Carefully wipe up any spill of battery fluid. It is sulfuric acid which is corrosive and can "burn" you or eat holes in your clothing. If you come in contact with battery acid, flush the area with water.

If your battery is a "no maintenance" battery, do not remove its caps, but charge it slowly. If you cannot charge it slowly, remove the caps, charge it, and then add water if necessary.

110 Volt Electrical Dangers

Whenever a boat is connected to a 110 volt alternating current (AC) from ashore or generated aboard, serious dangers may exist. The danger is greatest in a boat with a metal hull, but it is also present in any boat with metal fittings, propellers, or outdrives below the waterline.

The most common source of AC problems is the connection between the boat and the power wiring ashore. If the fittings ashore will accommodate only two prong connectors, danger exists since the circuit is not grounded. If the fittings accommodate three prong connectors, a simple, plug-in three prong, AC circuit tester, readily available at a variety of sources, can be used to test the correctness of the wiring. Incorrectly wired circuits are dangerous. Should the tester show an incorrectly wired circuit, don't use the circuit.

Even though your tester shows that the onshore 110 volt source is properly wired, the circuit should be protected with a Ground Fault Circuit Interrupter (GFCI or GFI). Portable, plug-in GFIs are available. Carry one with you. When the circuit does not have a GFI, use yours. Plug it into the source and then plug the cable from your boat into it. Under some circumstances if a short develops in the circuit, the GFI will immediately disconnect the power source.

All 110 volt appliances on board, such as a stove, refrigerator, or air conditioner, should be grounded to a common ground connection. If the "hot" wire of any of these appliances becomes grounded to its chassis or frame, then all grounded metallic components of the boat are energized. A GFI will interrupt the flow of current immediately if this happens. If not, a hazard is present for anyone on the boat or in the water nearby. It is best to stay out of the water if nearby boats are connected to AC current ashore. If you must go in the water to retrieve something, unplug your boat and nearby boats.

Direct Current Problems

The direct current (DC) supplied by your battery can be a source of severe damage to metal parts of your boat. Unless the "hot" wire to your bilge pump is properly sealed from the bilge water, DC current can leak from the wire to metal fittings in the bilge, such as the propeller shaft, through-hull fittings, and other metallic parts of your vessel. It then seeks a ground and takes part of the metal with it. This electrolytic action can rapidly destroy metal parts of a boat. Although potentially damaging to immersed metal parts, the 12 volt DC system by itself does not present a shock hazard to someone in the water.

Preventing Electrical Problems

There are some simple steps you can take to reduce the hazards of damage from DC current:

- Keep electrical wiring out of the bilge,
- Use only water-tight connections if there is any possibility of immersion in bilge water,
- Install a battery isolation switch,
- Make certain there is a fuse or a circuit breaker in the main distribution line from your batteries and as near your batteries as possible,
- Use only recommended size fuses or circuit breakers in your accessories connection panel,
- If new wiring is added to your boat, be certain that it is large enough to carry its intended load without overheating,
- Have any worn or frayed wires replaced by a competent marine electrician as soon as possible, and
- Inspect all metal fittings at frequent intervals for electrolytic or galvanic corrosion.

You can also reduce the potential damage and hazards of AC current by:

- Use a "plug in" tester to screen for potential problems in the on-shore service line,
- Don't use the on-shore service line unless you know it is correctly wired,
- Use a galvanic isolator that has been tested and approved by Underwriters Laboratories to allow AC current to flow to ground while preventing stray DC current from following the same path,
- Properly fuse all AC circuits or install circuit breakers,
- If new wire is installed in your boat for any AC circuit, be certain that it is heavy enough to carry the intended load,
- Have worn or frayed wiring replaced immediately, and
- If you are certain that the on-shore power source is properly wired, install a GFI between your vessel and the power source.

MAINTENANCE

"An ounce of prevention is worth a pound of cure." There are many things you can do to prevent problems. Most of these you do while tied up at a pier or ashore and before you are on the water and have engine failure.

This chapter has described several things you can do to keep your engine operating efficiently. You should also read and carefully follow the manufacturer's recommendations as given in your owner's manual. Follow them exactly. Don't take shortcuts.

For most boaters, maintenance procedures fall into three groups: routine maintenance, winterizing, and spring fitting-out.

Routine Maintenance

Follow a periodic maintenance plan for your engine based on the manufacturer's recommendations. Make a check-list of what you should do and when you should do it. Keep a log of the hours you run your engine. An engine hour meter helps in this respect but is not essential.

An important part of engine maintenance is keeping it clean. Likewise, keep the compartment of an inboard or stern-drive engine clean. This is not just a matter of good taste. It is a safety consideration. Oil in a bilge is a safety hazard. Remember, it is against the law to pump out oily bilge water into the water around you. It leads to environmental pollution, big fines, and embarrassment if it is pumped out into the water.

Lubrication

Systematic lubrication of your engine and its power transmission system is essential for optimal operation and long-time service.

Crankcase Oil. Change the crankcase oil in your stern drive or inboard engine at the intervals recommended by its manufacturer. Some manufacturers recommend that you change the oil filter each time you change the oil. This may seem excessive but why run clean oil through a dirty filter? Changing the oil in most marine engines is a dirty job but changing the filter adds little to it. Change the filter when you change the oil. Then clean up the boat and yourself.

Changing the oil in a stern drive or inboard engine is not an easy task because of the placement of the engine. The engine is placed as low in the boat as possible to keep the boat's center of gravity low. For inboards, this also keeps the angle of the propellor shaft as nearly parallel with the water's surface as possible.

Pumping the Crankcase. Pumps are available to remove crankcase oil through the dip stick tube. These pumps are either manually or electrically driven. They are also difficult to operate because of the size of the dipstick tube. Before you use a pump, warm your engine thoroughly so its oil is as thin as possible and will flow more easily. Be careful not to burn your hands with the hot oil.

Wash It Out. To clean hard to reach areas of the bilges, put a little water in them. Then add about half a cup of liquid detergent. After you have run your boat for a few hours, pump the bilge into a container (not overboard) for easy, and legal, disposal. While the water and detergent are in the bilge, keep your electrically operated bilge pump turned off to avoid an accidental "pump-out" overboard.

Fig. 8-14. Absorbing Oil in a Bilge
(Photo courtesy Aqua Power Corporation)

Check the Oil Level. In stern drive and inboard engines, check the crankcase oil level each time you use your boat. Check it before you start your engine. Check the oil in the transmission at regular intervals. Change it every 200-300 hours.

Lower Unit Care

Lower units on either outboards or stern drives contain oil to lubricate their gears. They require special care. Each unit has two oil cap screws. The upper one is for checking the oil level. The lower one is for draining old oil and adding new oil.

Change the gear case oil at regular intervals. Some manufacturers recommend changing it at least once each season or each 100 hours of operation whichever comes first. Check it at other times to see if there is enough oil in the case and to see that water has not intruded. The oil should be clear and without metal filings. If it is milky, it probably has water in it. It needs immediate repair.

To check the oil, remove the upper cap. The oil should be at or just below this opening. To fill the case with oil, remove both plugs and drain the old oil. The new oil is in a plastic, squeeze type bottle. Cut the tip off the nozzle and insert the nozzle in the bottom hole. Fill it until oil comes out of the upper hole. Replace both plugs.

Grease the Fittings. Most outboards and outdrives have zerk fittings to lubricate moving parts and cover latches. Lubricate them with marine-type grease from a grease gun. In salt water use, lubricate them every 30 days. In fresh water you may do it every 60 days.

Many stern drive engines have one or more zerk fittings or grease caps on the gears that connect the drive shaft to the lower unit. Lubricate these as recommended by the manufacturer.

Check Hydraulic Fluid. Some lower units and most larger outboards use hydraulic fluid in their lift mechanisms. Some also have hydraulic steering that uses hydraulic fluid. The hydraulic fluid for these purposes is stored in reservoirs. Check their levels frequently.

Checks While Lubricating

You can check several other things while you are changing the engine oil and filter.

Check Your Bilge Pumps. Check your bilge pumps by operating their switches manually. They should operate with the main battery switch in the off position. If they do not operate, first check the fuses or breakers. Then check the battery and the wiring.

Check for Oil Leaks. When there is oil in the bilge under the engine, look for its source. First, check to see if oil is leaking from the oil filter. If this is not the source, check the tightness of the crankcase bolts and transmission. Your oil filter should only be hand-tightened but it should not leak. After you change the oil, start the engine and check to see if the filter is leaking.

Check the Stuffing Box. If your engine is an inboard, check to see how much water is coming through the propeller's stuffing box. The amount of water in the bilge gives you some sign. A drip rate of a few drops per minute is normal. When the bilge water level or the drip rate is high, tighten the packing nut slightly. Do not over-tighten it. Some water must come through for proper operation. If tightening the packing nut does not solve the problem, change the packing.

Check the Drive Belts. Check the condition and the tension of the drive belts on alternators and water pumps. They should be flexible and resilient, and should not have frayed edges. A belt tension measuring tool is available, but few recreational boaters have them. Most simply press the belts at their mid-points. The belt driving the alternator should have about 3/4 of an inch "give." Other belts should have about 1/2 of an inch.

Ignition System Maintenance

Check your spark plugs at least annually. If they are pitted, replace them with new ones. Always use the size and type recommended for your engine. When replacing them, do not over-tighten them. When reinstalling the ignition wires, put about one cc (.06 cubic inch) of a silicone based grease inside each rubber cover. This helps prevent poor connections due to corrosion. Type Z-5 is recommended. It is available at most electronics stores.

Fuel System Maintenance

Many marine engines have fuel filters. Clean them periodically for best motor performance. These filters usually have a fine wire screen. Clean their containers with a clean, dry cloth. Clean the screen by shaking it into a clean, dry cloth.

Water Separation Filter. If you have a water separation filter in your fuel line, change its element annually. If you get a tankful of "wet" gas or if water collects in your fuel tank from condensation, your engine will run rough or raggedly. You can sometimes correct this condition by slowing your engine speed and running it until the water is cleared out. If your engine is diesel and you get a tankful of "wet" fuel, open the fuel filter drain cock and drain the filter. It may be necessary to replace the fuel.

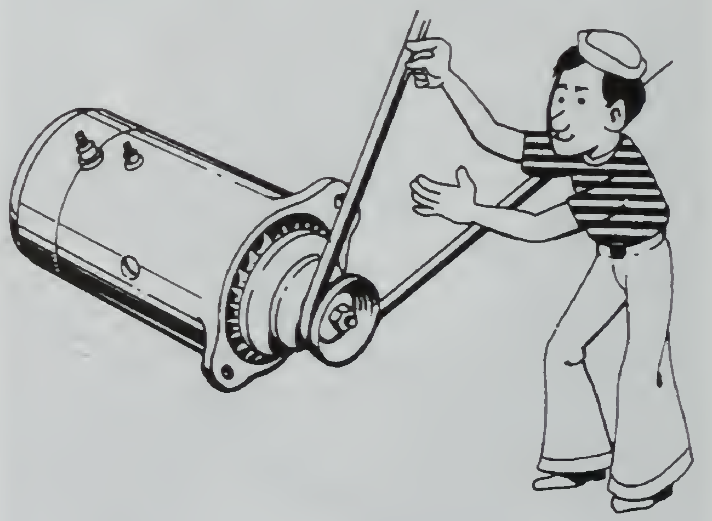


Fig. 8-15. Check Your Drive Belts

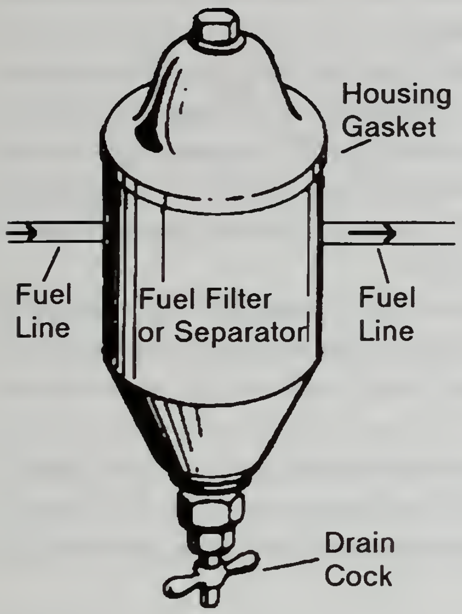


Fig 8-16. Diesel Fuel Filter or Separator

Cooling System

Both stern drive and inboard engines have cooling system hoses. Whenever you open the engine hood or hatch, inspect the hoses. If one of them ruptures while you are underway and you do not have a spare, you have a serious problem. The hoses should be firm. If they have soft spots or collapse easily, replace them.

Galvanic Action

Modern marine engines and lower units use a variety of metals. When you immerse two dissimilar metals in a solution such as salt water, an electrical current passes between them. This galvanic current will eat away one of the metals. Although this occurs less rapidly in fresh water than in salt water, it does occur to some degree because of impurities in the fresh water.

Metals can be arranged from "most noble" to "least noble." When dissimilar metals are immersed in impure or salt water, a galvanic current flows from the less noble to the more noble metal. This eats away the less noble metal.

Sacrificial Zincs. Zinc is one of the least noble of the metals. Zinc plates or bars are used to prevent destruction of metal parts by galvanic action. They are attached to the lower units of outboards and stern drives, the rudders of inboards, and the heat exchangers of many engines with closed cooling systems. Instead of the galvanic action eating away parts of the engine or outdrive, it eats up the zinc. The engine parts are protected. The zincs should be replaced when they are about half eaten away.

Propeller Maintenance

Unless a propeller is damaged, it needs little attention. If it has been damaged, repair or replace it. Damaged propellers can cause vibration and destroy propeller shaft bearings.

When you install your propeller, grease its shaft with a good quality marine grease. This will make it easier to remove.

Propeller locks are available to prevent theft. Propellers are expensive. Protect yours from theft.

WINTERIZING YOUR BOAT

There are several important guidelines for winterizing your boat if you do not plan to use it during the winter months. The first guideline is, the more you do in the fall, the less there is to do in the spring. The second is, the

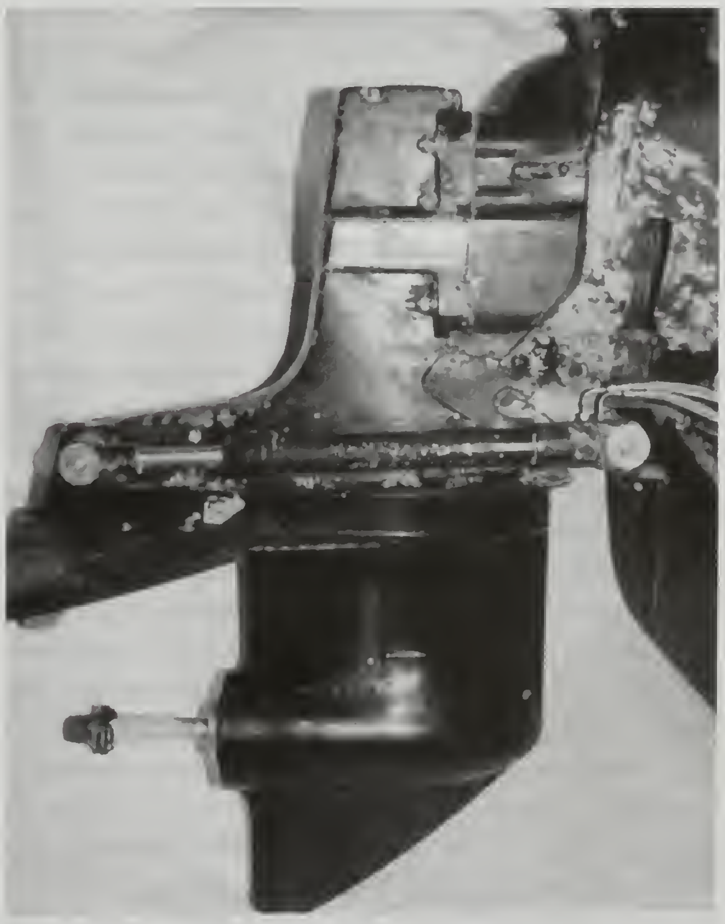


Fig 8-17. Corrosion Resulting from Galvanic Action

greater the danger of freezing, the more important it is to store your boat ashore. And a third one is, list the things you have done to lay your boat up. In the spring, check this list to see what you need to change back. For example, if you remove the bilge plug from the boat, include an item on the spring list to remind you to replace it. A fourth guideline is, consult your owner's manual for lay-up procedures not covered in the following general discussion. The manufacturer of your engine may recommend different procedures than those described.

Oil and Fuel Systems

Change your oil. The old oil in your crankcase contains residual acids and may contain water. Acids can damage an engine during the winter. Warm the engine, then drain the oil. Replace the filter and fill the crankcase with clean oil. For a boat on land, connect a fresh water adapter to the engine and run the engine for several minutes. This circulates the clean oil to all parts of the engine. While the engine is running, check the filter for leaks.

Fuel Tank

Many people have had problems with old gasoline in engines. For example, if you don't run the gas out of your lawn mower the last time you use it in the fall, its carburetor will gum up. The motor will not start in the spring. You can prevent the problem in your lawn mower by using all the gas in it before putting it away. Do the same thing with your boat engine.

If you have a small outboard and use fuel from a portable tank, disconnect the fuel line. Now, run the engine until it is out of fuel. Do this each time you use it and especially at the end of the season. Buy new fuel next season.

If you have a built-in tank, stabilize its gas before you put it up for the winter. You can get an additive at most marine supply stores to protect it from deterioration for six months or longer. Stabilizing the gas is worth the price of the additive.

Now, top off your fuel tank but don't fill it completely. If you do, gasoline will stand in the neoprene fill and vent pipes and may soften them. If you use diesel fuel, add a deicer and an antimicrobial agent.

Gasoline Engine

Shut off the gas supply and run the engine out of gasoline. While it is running, fog the carburetor with a coating oil by spraying it into the carburetor vents. The oil will coat internal surfaces and will prevent rusting and "freezing" of moving parts.

Cover the carburetor vents with plastic and tie it tightly. This prevents moisture-ladened air from entering and corroding carburetor parts.

If your engine is a diesel, it is not as important to fog it out. Furthermore, it is a difficult task. Don't undertake it unless you know what you are doing.

Cooling Systems

Fresh water left in a cooling system will freeze and damage the engine. If you have an outboard or stern drive on land or on davits, leave it in the normal operating position at least until all water has drained from it.

If you don't have antifreeze in the closed portion of your cooling system, add it now. Fill it with a 50 percent mixture of permanent antifreeze (ethylene glycol). Don't use pure antifreeze as it will gel in very cold weather.

Care of Lower Units

Lower the outdrive or the outboard as far as possible to let the water drain out. Make sure that drain holes are open. Check the oil level. If you haven't replaced the oil during the operating season, replace it now. Then you won't have to do it next spring.

Ignition System

Remove the spark plugs and inspect them. Replace any worn or pitted ones. Be careful not to drop them. Their ceramic stems will crack and they will be useless.

Store your batteries in cool, dry storage. If possible, connect them to a trickle charger to keep them fully charged. Make sure that there is enough water to cover their plates. If you leave batteries in a boat that is stored outside, they will gradually discharge and then freeze.

You may want to leave a battery aboard to operate a burglar alarm or a bilge pump. If so, see that it has a full charge and has enough water. A discharged battery will freeze and then be useless. Given enough time an unused battery will discharge itself and be useless.

Don't depend on a battery aboard to operate your bilge pump. The pump, battery, or float switch can fail. If your boat has a chronic leaking problem, store it ashore.

Freshwater System

You must winterize your fresh (drinking) water system. Drain it and then add antifreeze. *Do not use ethylene glycol. It is poisonous.* Instead, use a nontoxic antifreeze. It is available at most marine supply stores. If they can't get it, many people use cheap vodka.

Heads

If your head has a holding tank, drain it and then add disinfectant and antifreeze. Pump the antifreeze through the bowl and into the tank.

For other heads, see the manufacturers' recommendations.

SPRING FITTING-OUT

Look at your winter check list. You will need to undo some of these items. For example, put in the hull drain plug. Remove the plastic covers from the carburetor vents. If you did not do all of the things on the winterizing list, add them to your spring list.

Out of the Water

Batteries. Before you put your boat in the water, reinstall the batteries. If you did not remove them, check the levels of their fluid and their charges. Add distilled water and charge them as necessary. Clean and tighten the clamps.

Items to Check. Inspect the following items. Service or replace them as needed:

- ✓ Lubricate all seacocks.
- ✓ Close all seacocks that you opened in the fall.
- ✓ Inspect hoses and hose clamps.
- ✓ Inspect the engine water intake strainer to see that it is free of corrosion and properly secured.
- ✓ Inspect the hull for cracks and blisters.
- ✓ Inspect zincs.
- ✓ Inspect the fuel tank for corrosion and leaks.
- ✓ Inspect the bilge blower hoses for leaks.
- ✓ If you have a stern drive, inspect the bellows for dried, cracked, or deteriorated spots.
- ✓ Inspect power steering and power trim oil levels.
- ✓ Inspect and lubricate steering and control cables.
- ✓ Inspect the fire extinguishers.
- ✓ Inspect the galley stove for loose fittings or leaking hoses.
- ✓ Inspect the bilge pump and float switch.
- ✓ Inspect your pyrotechnic distress signals. Replace outdated ones. Keep old ones aboard as spares.

In the Water

After your boat is in the water, check all seacocks. Before you start your inboard engine, loosen the stuffing box nut. Check to see that it is dripping several drops per minute. Inspect the rudder packing box for leaks.

You are now ready to start your engine.

TROUBLESHOOTING

The environment in which boats are kept and used is hard on everything on board. It is particularly harsh on electrical parts so this is where problems most often occur. Failure of such equipment is usually the result of corrosion at electrical connections and switches.

For example, radios often fail because of faulty antenna connections. The same problem may cause a light not to come on. Brush the terminals or shine them up with fine sandpaper. Chances are that they will now work. Plug-in equipment may fail for the same reason. Clean the connectors.

Engine Will Not Turn Over

You get to your boat and prepare to start the engine. Of course you do all the right things. You open the hatch (if you have an inboard or stern drive), and lean over and smell for fumes. If your boat has a through-hull fitting for cooling water intake, you turn it to the open position. You check the engine oil level and you turn the blower on and let it run.

You also check the steering and the clutch and throttle control to see if they are operating. You lower your outboard or lower unit and pump the throttle full forward, full back, and then to its start position. Now, you insert the ignition key and turn it to start the engine. Nothing happens.

Check Your Clutch and Throttle Control

The first things to check if the starter doesn't work are the throttle and clutch controls. A marine engine should not start unless it is in neutral. In some systems there are separate throttle and clutch controls. In others they are combined in one control. If they are separate, put the clutch in neutral position. If they are combined in one lever, you can usually pull the lever sideways to disengage it. You can then keep it in neutral while you work the throttle forward and back.

Check Your Battery

When you turned the key, did you hear the starter solenoid click? If so, your problem is in the battery, the solenoid, or the starter. First, inspect the connections to the battery terminals. Are they clean and tight? If not, correct the problem.

If nothing happened when you turned the key, switch the ignition off. Turn on a lamp wired into the boat's 12 volt D.C. electrical system to see if you have enough power to light it. If it lights, turn the ignition switch to the start position. Does it still glow? If not, your battery is dead.

If you do not have a voltmeter or if the lamp fails to light, check the battery with a hydrometer. If the battery tests "dead," you will have to recharge it. If it will not take or hold a charge, replace it. If the battery is charged and you have solid state electronic ignition, the problem may be with your "black box." If so, consult a service technician.

Check for Loose Connections

If the battery is charged and its terminals and connectors are clean and tight, check for loose wires or connections to the starter solenoid. Tighten, as required. Your engine should turn over. If it doesn't, the problem is probably with the solenoid. If you are not a mechanic, take the engine in for repairs.

Engine Will Not Start

If the starter engages, and the engine turns over but doesn't start, check to see if you have fuel in your tank and to see that the fuel shutoff valve is open. If you have fuel, the problem is in the ignition or fuel systems.

Check to see if you have flooded the engine with gas. If so, you should smell fumes. If it's flooded, wait a few minutes and the problem should correct itself. Check your bilge again for gasoline fumes and run your blower for at least 4 minutes. When you try again to start the engine, don't advance the throttle.

Check the fuel filter and the backfire flame arrester to see if they are clean. If they are dirty, gasoline or air will not enter the engine. Both are necessary for ignition.

Your engine will also not get fuel or start if it has a faulty fuel pump. Replacing it is a job for a mechanic.

After all of this, if your engine does not start, check the wires to the spark coil, from the spark coil to the distributor, and from the distributor to the spark plugs. A loose wire from the spark coil or to the distributor makes ignition impossible.

Engine Runs Rough

Sometimes an engine will start and idle smoothly but become rough when accelerating or when running at cruising speed. A wire could be loose at a plug, the coil, or the distributor. The same condition results if you have a damaged spark plug or one that is overdue for replacement. A crack in the distributor cap gives the same symptoms. Cracks in a distributor cap may be too small to be easily seen.

If you replace the cap, be sure to use one designed for marine use. It will not admit gasoline vapors.

Engine Idles but Does Not Develop Full Power

Sometimes an engine will idle but will not develop full power underway. There are several possible causes. One that has already been described is a faulty condenser.

The most common problem is too much oil in the fuel mixture of an outboard. You may have put too much oil in the tank or your VRO may be malfunctioning.

In any engine, the carburetor could be out of adjustment. It will lose power if the fuel-air mixture is too rich. It will lose power and backfire if it is too lean. A kinked fuel hose or a slight blockage in the fuel line causes the same problem.

Outboards that are primed with electrical primers have the same problem if the primer fails. Failure limits the amount of fuel reaching the engine. Have it repaired or replaced.

If you are underway and your engine overheats or loses power, turn it off. Weeds or other debris may have fouled your propeller. If you have an outboard or a stern drive, raise it or the outdrive and see if you have weeds or other debris on the propeller.

There are other problems and solutions beyond this general discussion. You can learn a lot by reading your owner's manual and by listening to mechanics. In this way you can do many maintenance and repair jobs for yourself.

9

Lines and Knots For Your Boat

This chapter discusses the art of handling and working rope known as marlinspike seamanship. Its name comes from a tapered metal tool called a **MARLINSPIKE** used in working rope. The chapter discusses the composition, use, care, and selection of rope for specific uses. It also includes a discussion of the hardware associated with rope.

LINE OR ROPE?

When you buy it, you ask for rope. When you bring it aboard your boat you usually call it line. There are some exceptions to this convention.

One exception is when a line has a specific name. For example, the rope that keeps a sailboat's mast from leaning forward or backward is a **STAY**. **SHROUDS** keep the mast from leaning sideways. An anchor line and its fittings are a rode. The line that secures a dinghy to a larger boat is a **PAINTER**. A **SHEET** is a line that controls a sail.

Sometimes, though, a rope is a rope. For example, the line used to move a bell's clapper to make the bell ring is a bell rope. **BOLT ROPES** and **FOOT ROPES** help to control sails. There is also a tiller rope.

Sailboats use lines extensively. Powerboats use fewer lines and use them less often. Even aboard a powerboat, however, lines serve essential needs.

ROPE MATERIALS

There are three types of materials used to make rope: **NATURAL FIBERS**, **SYNTHETIC FIBERS**, and wire.

Natural Fiber Rope

Many different natural fibers have been used to make rope. These include manila, sisal, hemp, jute, cotton, and flax. Today, most marine supply stores sell only manila and cotton ropes.

Of the natural fibers, the best for all around use is manila. It makes good mooring lines, anchor lines, and rigging on sailboats. It is strong and durable. Under stress, it stretches minimally. Sisal is similar in appearance to manila. It is cheaper than manila but it loses strength when wet and may fail under stress.

You usually use cotton for flag **HALYARDS** and lead lines. It has good strength for its size and does not lose strength when wet.

Unfortunately, natural fiber lines shrink when wet. This means that in rainstorms you must maintain a careful watch. When natural fiber lines get wet, they shrink and you must ease them. Otherwise, the strain will damage them.

Synthetic Rope

Most boat owners prefer ropes made from synthetic materials. These ropes have good strength either wet or dry. They are stronger than natural fiber rope of the same size. In addition, they resist mildew, rot, and damage by acids and alkalis. Heat and sunlight damage them.

Nylon

The most commonly used synthetic fiber rope is nylon. It is the strongest of the synthetic ropes. It is more than twice as strong as manila rope of the same size. Nylon does not shrink when wet. It also resists chafing.

Nylon stretches more than any other synthetic or natural fiber rope. Even so, when you remove the stress, it springs back without damage to its fibers or construction.

Nylon's elasticity is both an asset and a liability. When used as an anchor or mooring line, it stretches and helps to absorb the shock of a boat's surge. Your anchor is less likely to lose its hold.

On the other hand since nylon stretches, you should not use it for lines that you must pull taut. Thus, you would not use it in the running rigging of sailboats. Running rigging is used for raising, lowering, and controlling sails.

Nylon's ability to stretch can make it dangerous if it breaks under strain. In such a case, it may work like an elastic band. A serious accident can result, for example, when one boat is towing another and the hardware comes loose. The line may act as a slingshot and hurl the hardware like a missile.

Polyester Rope

POLYESTER rope is known by trade names such as *Dacron, SeaGuard* or *Terylene*. It is about 10 per cent weaker than nylon rope but does not stretch nearly as much. Because of this, it is used on lines you draw tight such as on sails.

Nylon and polyester ropes look somewhat alike. Polyester line, though, is more pliable and smoother to handle. It does not stretch, and it is easier on your hands than manila rope. Under tension, polyester lines chafe easily.

Polypropylene Rope

Polypropylene rope is the least costly of the synthetic ropes. Its major advantage is that it floats. This makes it useful for ski tow lines and painters. Its ability to float keeps the painter out of the towing boat's propeller.

Polypropylene line deteriorates rapidly in sunlight. It then **PARTS** easily. Don't use it for anchor or mooring lines. You will probably lose your anchor and, perhaps, your boat.

Polypropylene line also has the disadvantage of having a hard texture. It may slip on a cleat and it can cut your hands. Knots tied in it often work themselves loose.

Special Ropes

Synthetic fibers are also used to make special types of ropes such as **SHOCK CORD**. Shock cord is a multi-strand rubber line with a synthetic cover and hooks or eyes on each end. The hooks or eyes make connecting it easy.

Shock cord can stretch up to twice its own length. You use it to hold things in place and to prevent halyards from slapping against the mast of a moored boat.

Table 9-1

**YACHTING ROPES—
WEIGHT AND STRENGTH COMPARISON**

SIZE	NYLON		DACRON		MANILA	
Diameter	*(lbs) Weight per 100 ft.*	*lbs Breaking Strength*	*(lbs) Weight per 100 ft.*	*lbs Breaking Strength*	*(lbs) Weight per 100 ft.*	*lbs. Breaking Strength*
1/4"	1.7	1,750	2.2	1,300	2.0	600
3/8"	3.5	3,200	4.5	2,850	4.0	1,350
1/2"	6.6	6,600	7.6	4,900	6.1	2,650
5/8"	10.5	10,200	12.4	7,800	13.1	4,400
3/4"	15.0	13,500	19.3	10,780	16.3	5,400
7/8"	20.5	18,500	23.5	14,000	22.0	7,700
1"	27.0	24,000	31.3	17,500	26.5	9,000
1-1/8"	34.5	32,000	40.4	23,500	35.2	12,000

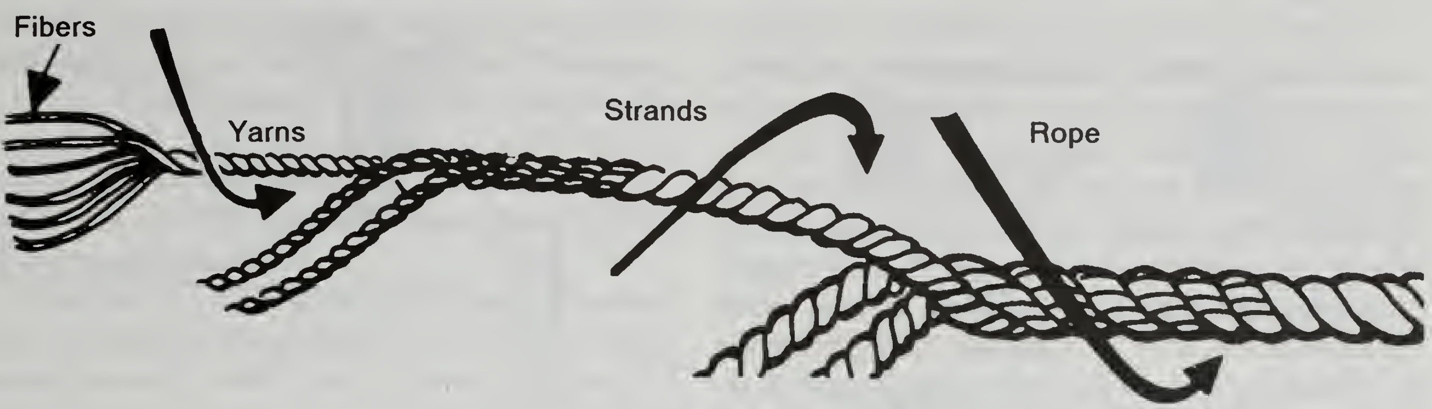


Fig. 9-1. Composition of a Line

Wire Rope

The **STANDING** or permanent **RIGGING** on a sailboat is usually wire rope. **RUNNING RIGGING** is often wire rope. Nearly all wire rope used on boats is stainless steel.[1] It provides maximum strength and minimum stretch. This makes it useful for davits, standing rigging, and halyards for hoisting sails.

KINDS OF ROPE

Rope is made in one of three ways, by laying, braiding, or weaving.

Laid Rope

LAID ROPE is made by twisting fibers together to form yarns. Yarns are then twisted together in the opposite direction to form strands. Strands are twisted together in the original direction to form the finished rope.

The direction in which the strands are twisted is the **LAY** of the rope. Thus, rope may be either **RIGHT-LAID** or **LEFT-LAID**. To tell the lay of a line, hold up a piece of the line. If the strands spiral upward to the right, the rope is right-laid. Most laid line used on boats has three strands twisted clockwise to form a right-hand lay.

Sometimes a larger line is desired. In this case, ropes are twisted together to form **CABLES** or **HAWSERS**. Hawsers are used on tugboats and to moor large vessels.

Wire rope is also laid rope. Strands or bundles of wires are twisted together to make it (see fig. 9-2). Heavier wire is used when strands are twisted than when bundles are twisted. This makes twisted strand rope stronger but at the sacrifice of flexibility.

Wire rope for standing rigging is called *1 × 19* (spoken as "one by nineteen"). This means it consists of 19 equal elements wound around each other (see fig. 9-2). It is strong but not very flexible.

Wire rope for running rigging is *7 × 19* (seven elements, each composed of 19 individual strands). Wire rope, called *7 × 7* (seven strands, seven elements in each), is also used for running rigging. Wire for running rigging is weaker than standing rigging wire of the same diameter, but it is more flexible.

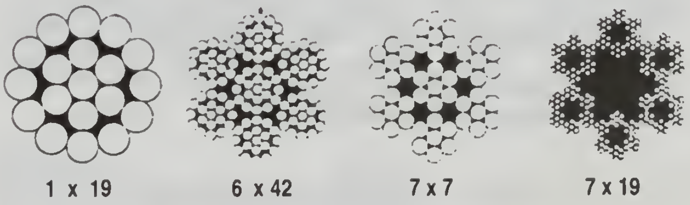


Fig 9-2. Cross Sections of Wire Rope

---

[1] Stainless steel resists rusting but does not remain rust-free forever. It is only stain-*less*.

The *6 X 42* wire rope illustrated in figure 9-2 has a fiber center like many wire ropes. Cotton, hemp, or manila are often used for the cores of wire rope, depending on the desired service and the size of the wire. The core adds flexibility to the wire and forms a cushion upon which the strands close in under heavy strain. Moreover, the core acts as a wick for the lubricant when the wire is "slushed" with grease or oil. Slushing keeps the wire supple and rust-free. Wire rope used on davits is often slushed.

Braided Rope

A second way to make rope is by braiding. This can be done by interweaving individual fibers or by weaving three or four strands. Braided rope is smooth like cotton clothesline. This makes it easier on the hands than laid rope. On the other hand, braided line can snag on pilings and other objects. If so, its strands may break and the rope becomes weakened.

Braided rope may be **SINGLE** or **DOUBLE-BRAIDED**. Double-braided rope has an outer braided cover over a separate inner braided core.

Small sizes of single-braided ropes, up to 3/8 inch, are used for sail bag ties, flag halyards, and similar special purposes. Most braided rope used on boats is double-braided.

Double-braided rope is stronger than laid rope of the same size. Single-braided rope has strength comparable to the same size laid rope. It costs more to make braided rope than laid rope.

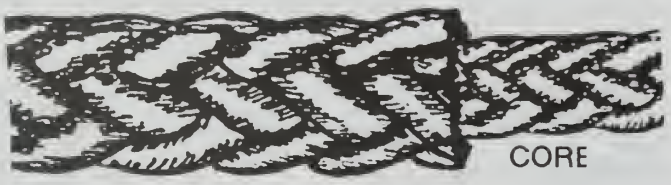


Fig 9-3. Double-Braided Rope

Webbing

Synthetic fibers are sometimes woven together to form a flat line called webbing. Webbing is used for a variety of purposes such as the retrieval line on a trailer. You may have seen it used for the backs and seats of lawn chairs.

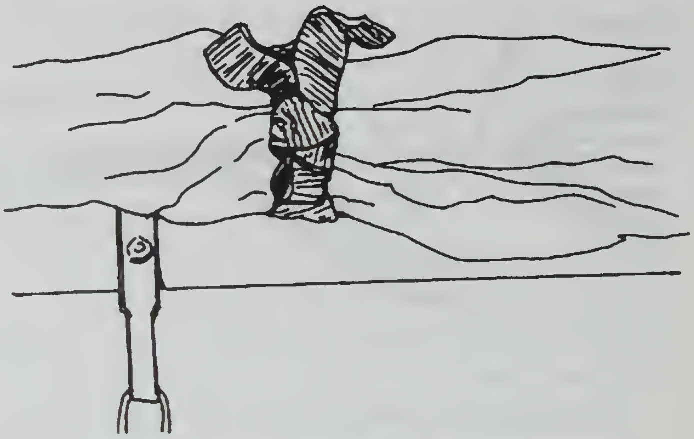


Fig. 9-4. Sail Stop With a Reef Knot

Webbing of woven nylon or polyester is very strong. Use it to tie down a dinghy on a larger boat or to hold a boat on a trailer. Webbing makes good sail stops since it holds knots so well. A sail stop is a tie used to hold a lowered sail to its boom.

MEASURING ROPE

The traditional way to measure the size of fiber rope is by its circumference (the distance around the rope). Today, most marine suppliers and boaters, however, describe it by its diameter. If you ask for a 1/2 inch rope you will get one with a 1/2 inch diameter.

Small diameter fiber rope is known as **SMALL STUFF**. When referring to small stuff, yarns are called threads. The size of small stuff depends on the number of threads it contains. For example, six-thread small stuff has six yarns of fiber twisted together. Small stuff is frequently used for **WHIPPING** or wrapping the end of a larger piece of rope to prevent its fraying.

SELECTING YOUR ROPES

Select each line for its specific purpose. Some characteristics to look for are:

- strength
- elasticity
- resistance to chafing
- resistance to sunlight
- resistance to slipping
- buoyancy
- ease in handling
- storage conditions

Small lines are suitable for securing small items, but most people have trouble holding on to them. The smallest line most people can conveniently hold has a 3/8 inch diameter. Choose larger-size lines for sheets, halyards, anchor lines, and mooring lines on anything but the smallest boats.

It is "penny wise and pound foolish" to use small mooring and anchor lines. During a storm, these lines are under heavy stress. The surge of your boat can cause a line to part. A limiting factor in choosing a line is the size of the cleat you will tie it to. In general, you will want to use the largest size that can be properly tied to it.

Large lines have less stretch per pound of load than smaller lines. Larger lines also take fewer turns around a winch to raise a sail, and offer more friction on the winch. Regardless of the size of the line, you may wish to wear gloves with palms and without fingers on a sailboat. They are designed to protect your hands from line burn while still keeping your fingers free.

The principal disadvantage of large line is cost. Large line costs more than smaller line, and you will need a larger cleat to which to tie it. On a sailboat, larger lines call for larger **BLOCKS** (pulleys). These are also an added expense.

CARE OF ROPE

All rope requires some care. Stainless steel wire rope needs the least. The time and trouble you take in caring for your lines are well-worth the effort. You will be repaid by greater safety and longer line life.

Uncoiling Rope

Proper care begins as soon as you buy your rope. Open new coils carefully. The rope can easily tangle and kink. This makes handling it more difficult and can weaken its fibers.

If you buy a coil of natural fiber or nylon rope to use as an anchor line, uncoil it carefully. Place the coil upright so the end of the rope inside the coil is at the bottom of the hole. Now reach in and pull out the desired length of rope.

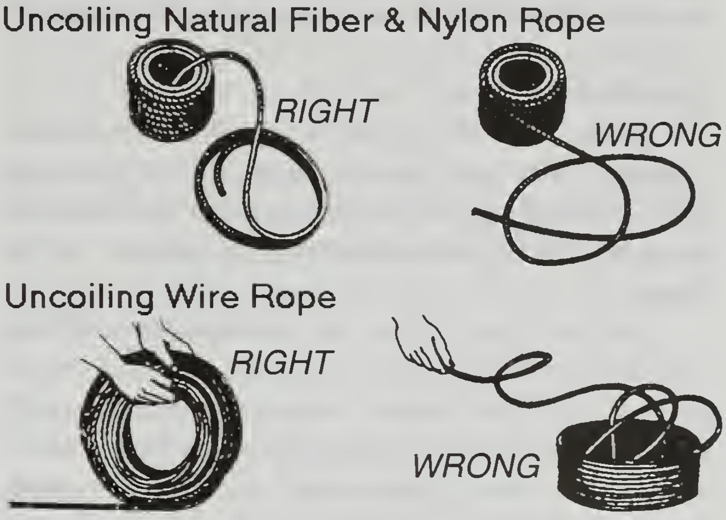


Fig. 9-5. Uncoiling Rope

Both braided and wire ropes usually come on reels or spools. If your rope came on a reel, roll it off. Do not try to uncoil it. If you try to uncoil a reel, there will be a kink in the rope for each turn taken off the reel. The same problem occurs if you take rope from a coil in an improper manner.

If you get a kink in your rope, remove it. You can make it disappear by putting a strain on the rope, but don't do it. It will weaken the rope at the point of the kink because some of its fibers will break.

Overstressed Lines

Never overwork or overstress a line. You may not see it, but too big a load on a line breaks its fibers and weakens it. You can check for deterioration in a natural or synthetic line by looking inside it. When there is grayish,

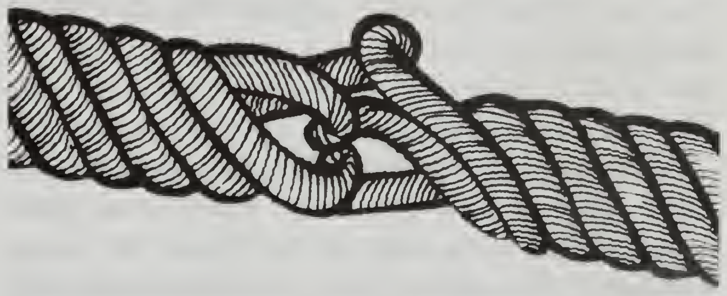


Fig. 9-6. Result of a Heavy Strain on a Line with a Kink in It.

powdery material, replace it. If your line has decreased in diameter, it has been weakened.

Dry Your Lines

Stow your lines in dry, well-ventilated places. This prevents accumulation of moisture. An ideal place to stow lines is on a shelf or grating. Do not stow other materials on top of them.

Natural fiber lines are susceptible to damage from mildew and rot associated with moisture. Salty lines absorb water. Wash them with fresh water after saltwater use. Then, thoroughly dry them before stowing. If you don't, they will mildew and rot.

You can stow synthetic fiber lines wet. If you do this, though, you introduce moisture into your **HOLDS** or lockers. Although synthetic fiber will not rot, it will mildew. This makes it look and smell bad.

Keep your lines away from sources of heat such as exhaust pipes. Heat is harmful to synthetic fibers. Don't get acid from your battery on a natural fiber line. It will destroy the line. Better still, keep all lines away from battery acid.

Chafing

If lines rub against hard surfaces, even highly polished chocks, they chafe and weaken. Wrap your mooring and anchor lines with canvas or leather to prevent chafing where they pass through chocks. Where mooring lines contact wooden or concrete piers, pass them through lengths of old garden hose. It will increase their useful life.

To get the most use of a mooring or anchor line and to maintain its safety, turn it end for end periodically. Anchor and mooring lines and lines on davits are examples of such lines. After you turn them around, they will chafe at different points.

Keep Your Lines Clean

Dirt, sand, salt, and oil are destructive to both natural and synthetic fiber lines. Dirt, sand, and salt crystals cut the fibers. Oil weakens them. To wash a line, put it in a mesh bag or pillow case and put it in a washing machine. In this way, it won't get tangled up, get new kinks, nor foul up the washing machine. *Mild* soap or detergent will not harm either natural or synthetic fibers. If the line is stiff, use a fabric softener.

Fraying

The ends of all lines will fray and **UNLAY** unless you treat them to prevent it. If you don't care what the end of your line looks like, tie a knot in it. This is unsightly and makes the line difficult to use. It will not easily pass through chocks and blocks.

When a synthetic line is cut from a coil by an electric cutter, it does not need care immediately. When it is cut with a knife or otherwise, you can use a match to get the same result as an electric cutter. The heat will melt the end of the line, and the strands will stick together. Eventually, though, the end will begin to unravel.

Another temporary means of treating the end of a line is by taping it. You can use marine, electrical, or adhesive tape. Sooner or later the tape will come off and the line will unravel.

A more permanent way to prevent fraying is by using an air-drying plastic developed for this purpose. You can even color-code your lines by this means. This is useful on a sailboat where several lines may end near each other.

Whipping the end of a line can keep it from unravelling temporarily. Figure 9-7 shows how to whip the end of a line.

To whip the end of a line permanently, as in figure 9-8, use Dacron or nylon thread. First, stitch the thread through the line. Next, make a series of tight turns around the line. The

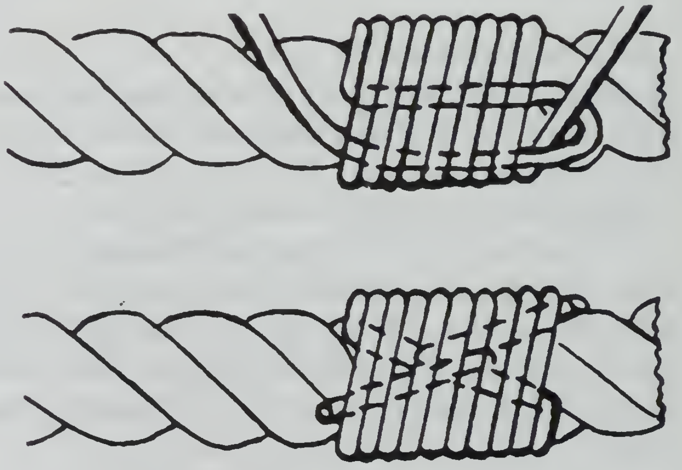


Fig. 9-7. Temporary Whipping

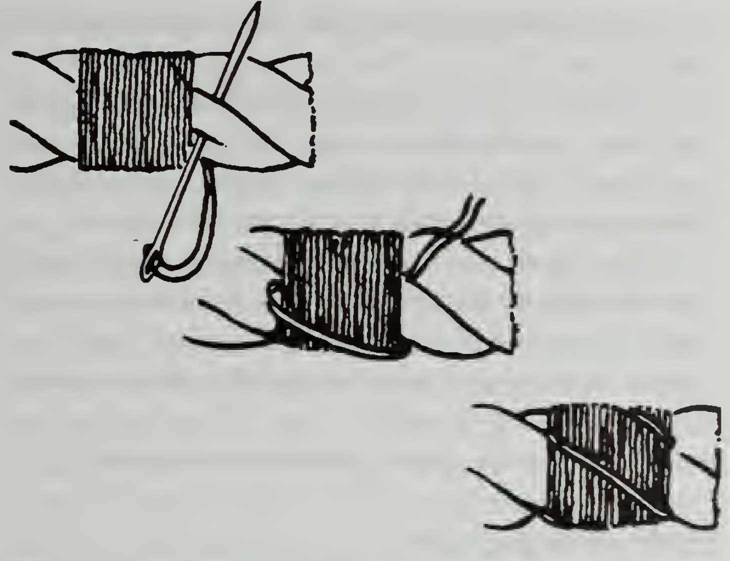


Fig. 9-8. Whipping

series should be about as wide as the diameter of the line. It should end about 3/8 to 1/2 of an inch from the end of the line.

After this, again sew through the line and stitch back through the turns to the next groove. Then bring the cord back over the turns along a groove between the strands. Stitch through the next strand and then back through the turns.

After making three sewed retaining threads, tie off the ends of the threads. Besides being decorative, a whipping like this is very functional.

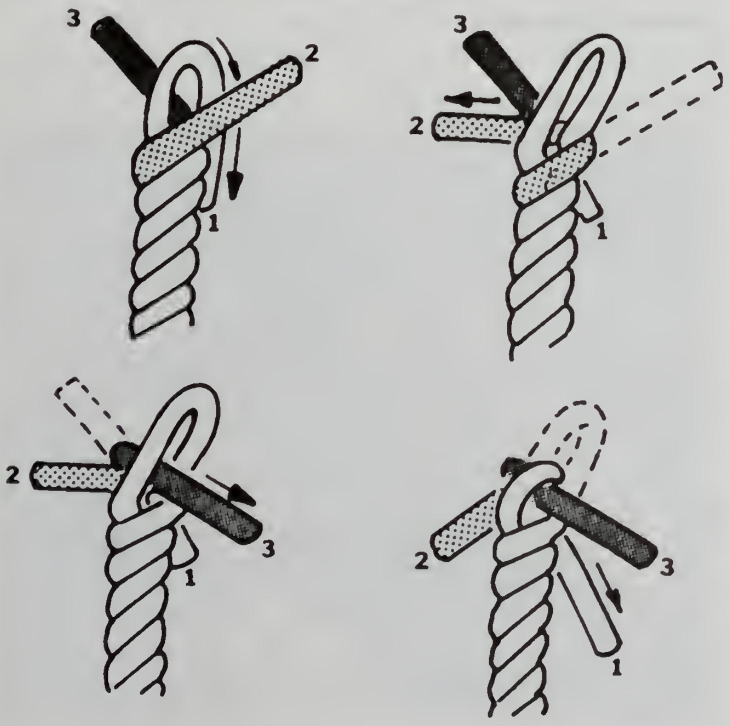


Fig 9-9. Crown Knot

If the end of the line does not have to go through a block, use a **BACK SPLICE** to keep it from fraying. This is done by first making a crown knot as in figure 9-9. Follow this by tucking the leftover strands over and under the strands in the main part of the line. Four or five tucks of each strand are enough to hold the splice securely. Synthetic fiber lines require more tucks than natural fiber lines since synthetic is slipperier.

Care of Wire Rope

Wire rope will serve you well if you take care of it. One of the worst things that can happen to it is to get a kink in it. This weakens it.

Galvanized wire rope, used frequently on davits, will rust and weaken. Special lubricants are available to keep it flexible and to protect it against rusting. You do not need to use a lubricant on stainless steel wire rope.

Even with care, galvanized wire rope will not last as long on your davits as will stainless steel wire rope. Considering the cost of replacing it, it may be cheaper to use stainless. Remember, though, that the load bearing capacity of stainless steel wire rope is less than that of galvanized wire rope of the same size.

Be careful when you run your hand along a wire rope. Under stress, some of the small wires break. They then stick out from the rope. Examine wire rope from time to time. You can do this by wrapping tissue paper around it and running it up and down the wire. If it shreds, it shows broken strands called fishhooks.

Breaks in the strands of wire rope mean it is damaged. Breaks lessen the load carrying ability of the rope. When there are more than a few fishhooks, consider replacing the rope.

MAKING UP LINE

Stow your lines neatly when they are not in use. How you stow lines depends on their intended uses. There are three methods of making up line—**COILING**, **FAKING**, and **FLEMISHING**.

Coiling a Line

If you plan to stow a line in a compartment or locker or hang it from a peg, coil it. Coil right-laid rope clockwise. Coil left-laid rope

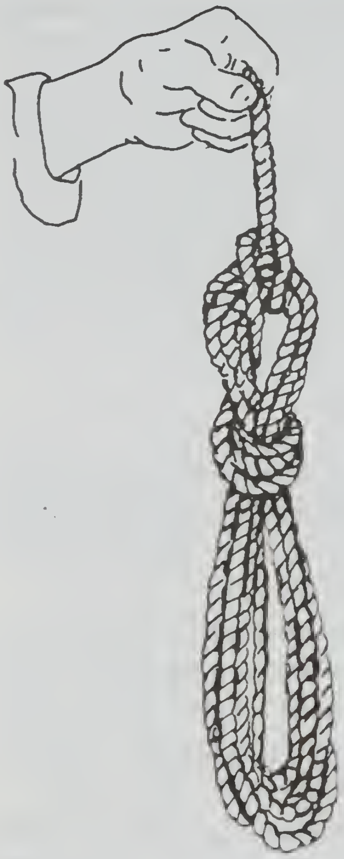


Fig. 9-10. Coiling a Line for Stowing

counterclockwise. If the line is right-laid, start by holding it in your left hand. Run your right hand down the line and sweep the line back to your left hand to form a coil. Continue until you have coiled all the line.

If you are going to hang the coil up, release the last coil and wind the line around the remaining coils several times. You can now pass part of this line through the coils to form a loop as in figure 9-10. Hang it from this loop.

Faking-Down a Line

On a small boat you can usually stow your anchor line by letting it fall into its well. If this is not feasible, try faking it down or flemishing it.

Faked lines run well in fast run-offs. Mooring lines, anchor lines, heaving lines, lead lines, running rigging, and other lines can be faked. Faking is sometimes known as flaking.

Faking-down consists of laying the line in figure eights called fakes. The fakes may overlap or lie clear of each other. Faking-down prepares the line to run out rapidly without fouling or kinking. Keep clear of a line when it is running out. You could become snarled in it.

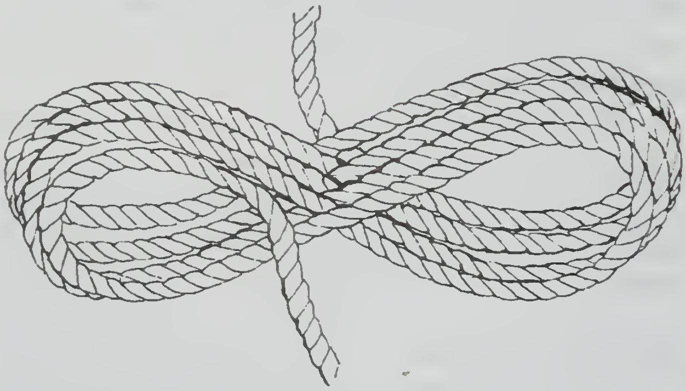


Fig. 9-11. Faking-Down a Line

Flemishing a Line

To give a line a neat, ornamental look, flemish it. To do so, coil the line flat on a deck or pier like a spring. Let each coil encircle the preceding one. Coil right-laid line clockwise. When you have finished, you can tighten the coil by laying both hands flat on the line at the center of the coil. Now, turn your hands in the direction that tightens the coil. This forms a tight mat.

A flemished line looks great. Flemish the ends of your mooring lines. You will be less likely to trip over them. But don't leave a flemished line on a varnished surface very long, especially overnight. The trapped moisture will spoil the varnished finish. If left for several days on a fiberglass surface, it may leave a nasty dirt stain.

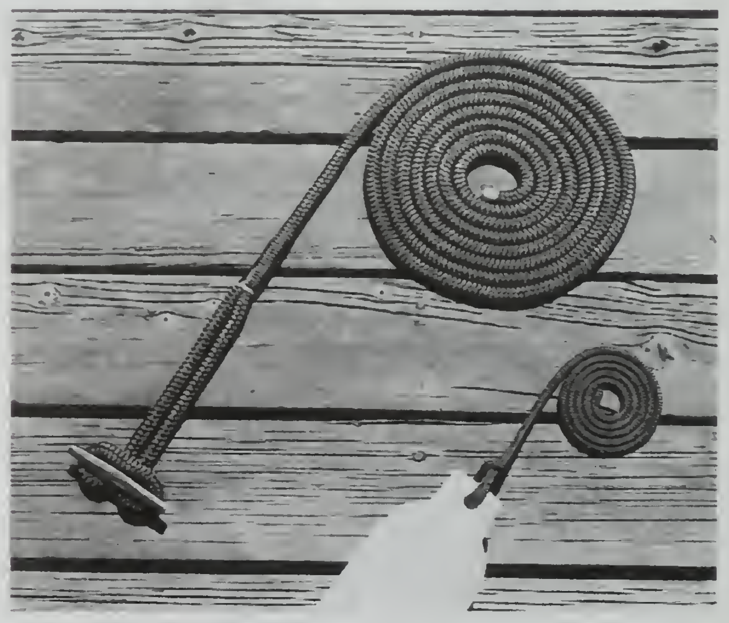


Fig. 9-12. Flemishing a Line
(Photo courtesy Rope Works)

KNOTS, BENDS, AND HITCHES

You use lines for pulling, holding, lifting, and lowering. Before they can do these things, you must fasten them to something.

The way you fasten a line depends on what you intend to do with it. The general term for these fastenings is **KNOT**. This term includes knots, **BENDS**, and **HITCHES**. Among sailors, if you tie a line to itself, the result is a knot. Thus, "knot" has both a general and a specific meaning.

A knot is a bend if you tie one line to another. If you attach a line to an object, you have made a hitch. There are exceptions to these conventions, as you will see.

You can learn something about tying knots by reading about them. If you are to become proficient, though, you must practice.

Knots and Line Strength

All knots depend on friction created by turns in the line for their holding power. Under a strain, friction weakens a line by breaking some of its fibers. Lines also weaken at splices because they depend on friction. On the other hand, splices weaken a line much less than other knots do. You can see how knots and splices weaken lines in table 9-2.

Characteristics of Good Knots

A good knot (bend, hitch) has certain characteristics. It holds well without slipping. It serves a practical purpose and does what you want it to do. It is easy to tie. It is also easy to untie after it has been stressed. If you can't untie a knot after you have used it, you will lose at least a portion of your line.

Parts of a Line

The parts of a line have names. These names make it easier to describe how to tie knots and to talk about them.

The **BITTER END** of a line is the end tied to a vessel. On some boats, you tie the bitter end of an anchor line to a bitt. A bitt is a heavy and firmly mounted piece of wood or metal used for securing lines. Bitter also describes how you feel if you see the bitter end of your anchor line go overboard. The other end of the line is the **WORKING END**.

Table 9-2

How Knots and Splices Reduce Strength of Rope		Remaining % EFF.
KNOTS	No knots or splices	100
	Anchor or Fisherman's bend	76
	Timber hitch	70-65
	Round turn	70-65
	Two half-hitches	70-65
	Bowline	60
	Clove hitch	60
	Sheet bend or Weaver's knot	55
	Square or Reef knot	45
SPLICES	Eye splice (over thimble)	95-90
	Long splice	87
	Short splice	85

A line has a **STANDING PART**. This is the main part of the line. A **BIGHT** is the middle part of a slack line (see fig. 9-13). When the bight is around an object or the rope itself, it's a **TURN**. When it is a complete circle, as in figure 9-13, it is a **ROUND TURN**. An **OVERHAND LOOP** is a small circle in the standing part of the line made by crossing the working end over the standing part. You make an **UNDERHAND LOOP** the same way except you cross the working end under the standing part.

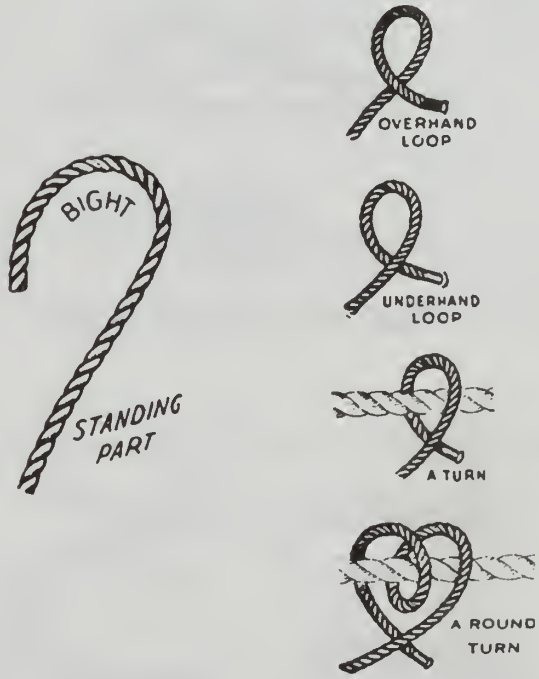


Fig 9-13. Parts of a Line

A word of caution in tying knots. Synthetic line is slick. Some knots will pull out of synthetic line unless you leave an extra amount of line projecting beyond the knot. Pull the knot tight.

Some Useful Knots

The array of available knots can be confusing. You don't need to know them all. Knowledge of a few good knots is better than a superficial knowledge of many seldom-used knots.

The knots, bends, and hitches described in this chapter are functional. They serve many purposes, and, except as noted, are as easy to untie as they are to tie.

Stoppers

A **STOPPER** is a knot tied in a line to prevent it from running all the way through a block. There are two commonly used stoppers.

Overhand Knot. You can use an **OVERHAND KNOT** as a stopper. You can also use it to *temporarily* prevent a freshly cut rope from unlaying or unraveling. It is not a good knot since it jams under tension and is then difficult to untie. You tie it by first making an overhand loop in the standing part of the line. Then you pass the working end up through the loop. Now, pull it tight.

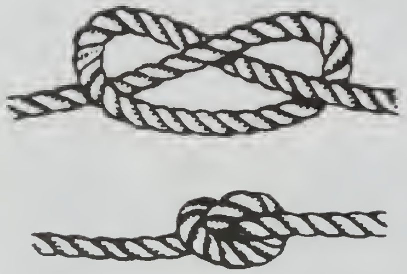


Fig. 9-14. An Overhand Knot

Figure Eight Knot. A **FIGURE EIGHT KNOT** makes a better stopper than an overhand knot does. Use it when heavy loads may occur. It is far superior to an overhand knot because you can untie it easily after it has been jammed. Use it on all lines on your sailboat except on your **SPINNAKER** sheets. These should always be free to run in an emergency. Tie the overhand knot by first forming an underhand loop. Now, pass the working end of the line over the standing part and up through the loop. You can untie it by pushing the working end back through the loop.

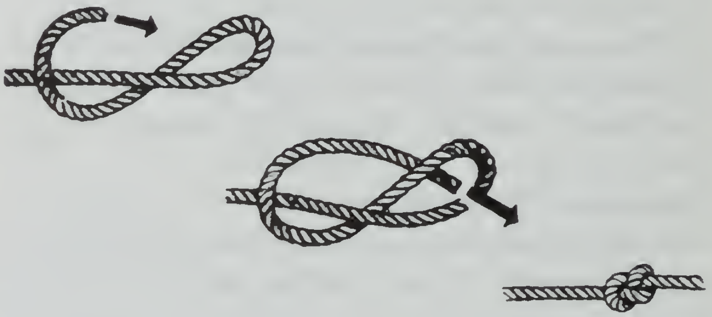
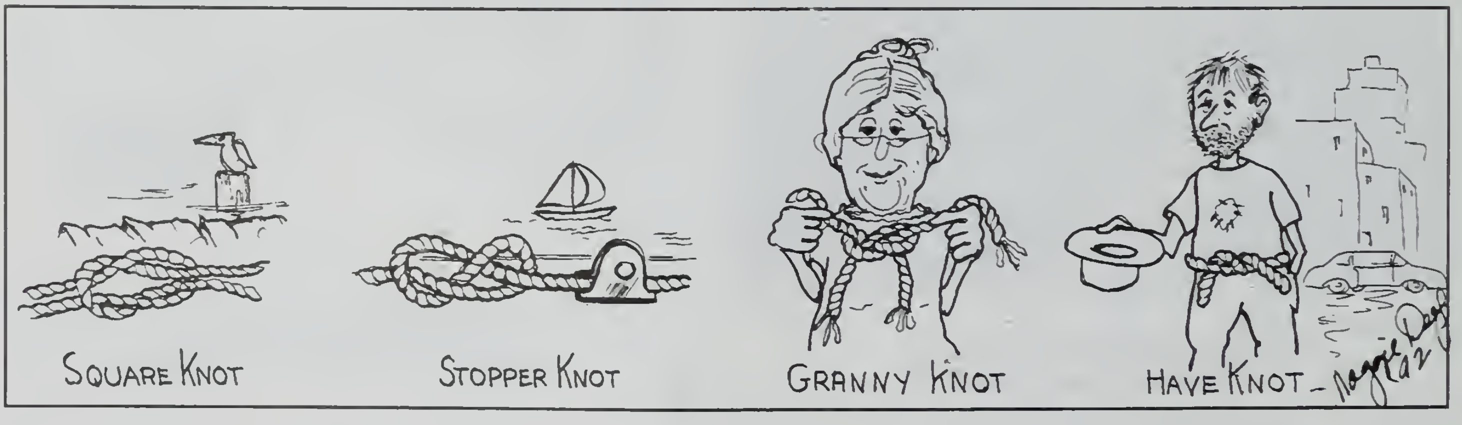


Fig. 9-15. A Figure Eight Knot

Reef Knot

A square knot is sometimes called a **REEF KNOT** (fig. 9-16). It is used to secure a **REEFED SAIL** to a **BOOM**. You can use it to tie together two lines of *equal* size or two ends of the same line. If you use it with lines of unequal size, it will probably slip and untie.

A reef knot is useful only when it is not subject to a heavy load. It is useful for tying packages. Under a heavy load it jams and is difficult to untie. If you apply unequal tension, such as a jerk on one side, it is apt to turn into two half hitches. If so, it may slip.



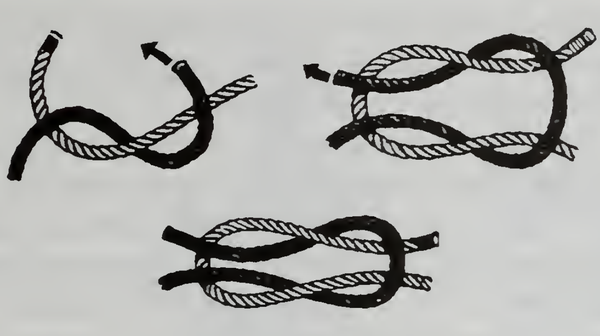


Fig 9-16. A Reef Knot

To tie a reef knot, hold one line in your left hand and the other in your right hand. Now pass the end in your left hand over and under the line in your right hand. Following this, pass the same end back over and under the other end. When you finish, it should look like figure 9-16. The end of each line should emerge from the side it entered and lie parallel to its own standing part. If it doesn't you have tied a "granny" knot. It will slip under tension.

Sheet or Becket Bend

The **SHEET** or **BECKET BEND** is also called a **WEAVER'S KNOT**. You use it to tie together lines of equal or different sizes. There are three forms of the knot: sheet bend, **DOUBLE SHEET BEND**, and **SLIPPERY SHEET BEND**.

Sheet Bend. You tie a sheet bend by forming a bight in the larger line. Pass the working end of the smaller line up through the bight, around both parts of the larger line, and back under itself. If you are going to stress this knot, tie the ends of both lines to their standing parts with small stuff. If not tied down, alternate loading and unloading of the knot can untie it.

Double Sheet Bend. A double sheet bend offers more security than a sheet bend. It is especially needed when one line is considerably larger than the other. You tie a double sheet bend by forming a bight in the larger line. Next, pass the working end of the smaller line up through the bight and around the standing part of the larger line. Now take another turn around the standing part of the larger line with the smaller line and pass it back under itself.

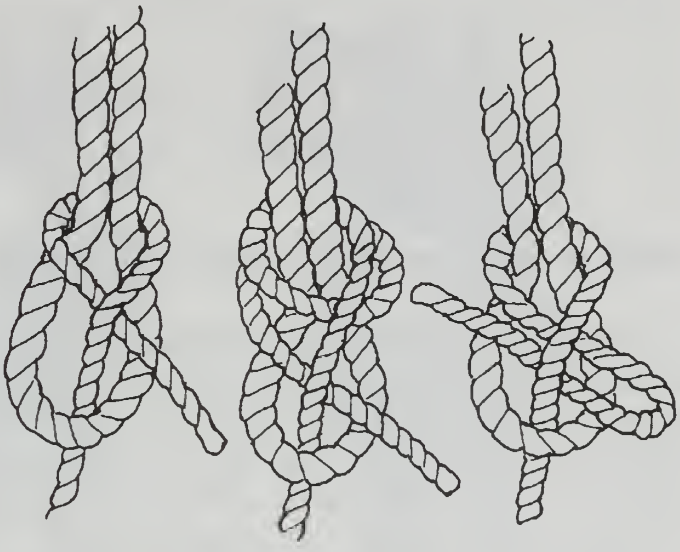


Fig. 9-17. Sheet Bend, Double Sheet Bend, and Slippery Sheet Bend

Slippery Sheet Bend. A slippery sheet bend is a variation of a sheet bend. Tie it like a sheet bend but don't tuck the line under itself. Instead, form a bight in the end of the smaller line and tuck this bight under the standing part of the smaller line.

A slippery sheet bend is easier to untie than a sheet bend. It is also less secure. A knot is "slippery" if it ends in a bight. This makes it easy to untie under tension.

Clove Hitch

You use a **CLOVE HITCH** to tie a line to a piling or bollard or a fender to a rail as in figure 9-18. Be careful with this knot. It will slip if not under constant tension. The loading and unloading of a line caused by a boat surging on its moorings can undo the knot. Thus, a clove hitch is a temporary means of securing a boat. A clove hitch will jam under a load. If you can't ease the tension on the line, you can't untie it easily.

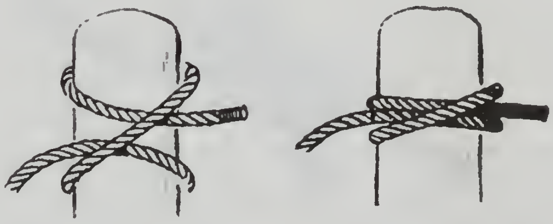


Fig. 9-18. A Clove Hitch

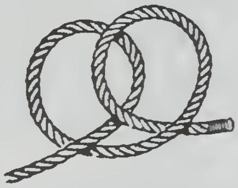


Fig. 9-19. An Alternate Way To Tie a Clove Hitch

You tie a clove hitch by passing the working end of the line twice around the object to which it is to be tied. The first pass is below the standing part of the line (fig. 9-18). The second is above the standing part. Finish by passing the working end under the second loop.

You can also tie a clove hitch by forming two underhand loops in the standing part of the line (fig. 9-19). Form the second loop on top of the first. You can now pass both loops over a bollard or piling.

You can make a clove hitch more secure. Run the working end around the bollard and over the standing part of the line. Complete the knot by passing the working end through the loop you have formed. You have now tied a **HALF HITCH**.

Two Half Hitches

Two **HALF HITCHES** are the same as a clove hitch tied around the standing part of a line. To make them, pass the working end of the line around the object to which the line is to be tied. Now, pass the working end of the line over the standing part and through the loop that is formed. This forms the first half hitch.

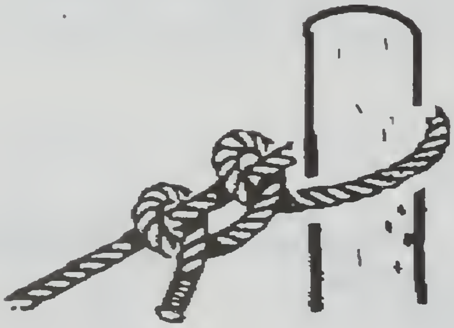


Fig. 9-20. Two Half Hitches

You form the second half hitch in the same way. Pass the working end over the standing part and back through the loop.

You can tie lines to rings, **SPARS**, piles, and posts with two half hitches. Under tension, two half hitches are easier to untie than a clove hitch. Two half hitches are a more permanent knot than a clove hitch. Under tension, the knot tightens. Even so, it is easy to untie.

Anchor or Fisherman's Bend

Use an **ANCHOR BEND** or **FISHERMAN'S BEND** to tie an anchor line to an anchor fitting such as a ring. You can also tie a fishing line or leader to the eye of a fishhook with the bend. It is a secure knot for bending a line to an object since it develops considerable friction. At the same time, there is less line chafe where it goes around the fitting. Thus, it is a strong knot.

You begin to tie the knot by passing the working end around the object twice, forming a loop and a turn. You then pass the working end over the standing part and through the loop and the turn. Following this, you again pass the end over the standing part and between the standing part and itself.

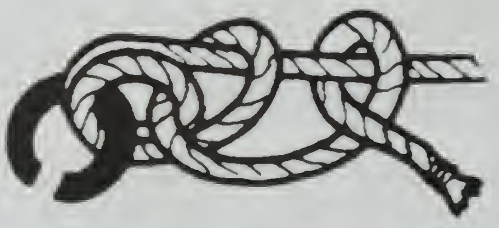


Fig. 9-21. An Anchor Bend

Actually, the anchor bend is much like two half hitches. Instead of passing around the object once, though, it passes twice. Additionally, you tie the first half hitch through the two loops instead of between the standing part and itself.

To make the knot more secure, tie the working end off to the standing part with twine.

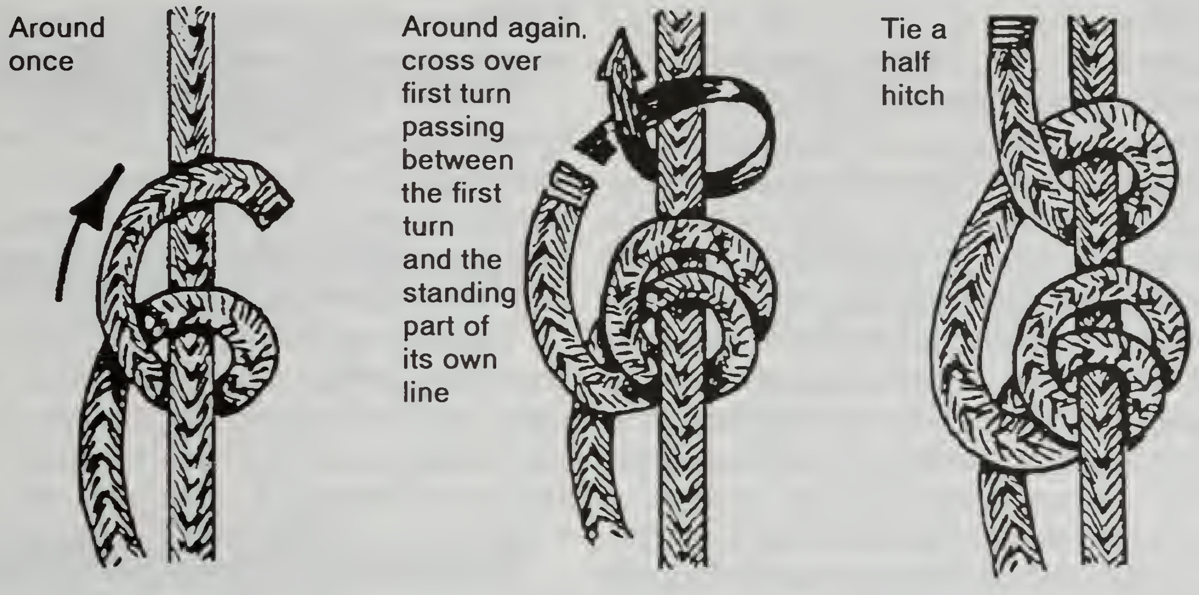

Around once
Around again, cross over first turn passing between the first turn and the standing part of its own line
Tie a half hitch

Fig. 9-22. A Rolling Hitch

Rolling Hitch

When you tie a **ROLLING HITCH** you tie one line to the standing part of another. You use it to tie a line to the working end of a second line. When you put tension on the first line, it releases the tension on the second. This allows you to adjust the second line. You can use it, for example, to hold a jib sheet while you release the sheet from a winch or relocate a block. You can also use it to adjust fender lines and awning tie-downs.

You tie the knot by passing the working end twice around the line to be held, as in figure 9-22. In each of these turns, the working end passes over the standing part of its own line. You then take a third turn around the line you want to hold. After this, the working end is passed under itself forming a half hitch. You must tie the first two turns on the side from which you will put tension on the standing part.

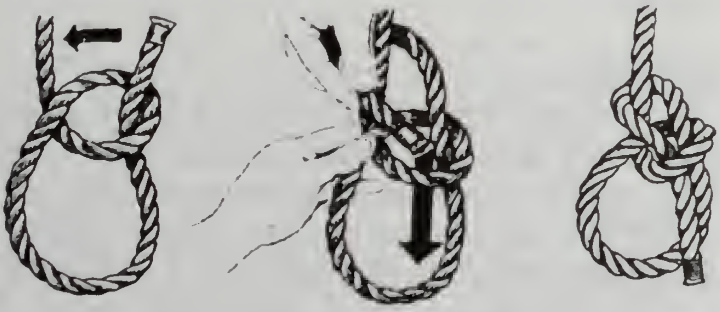


Fig. 9-23. Tying a Bowline

Bowline

The **BOWLINE** is a means of forming a temporary, fixed-size loop at the end of a line. It is the "King of Knots" because of its many everyday uses on boats and elsewhere. A bowline is easy to untie even after being under a heavy load. Just push the working end back through the loop around the standing part.

On board, bowlines tie lines to fittings, **JIB SHEETS** to **CLEWS**, and lines to anchors. You can also use them to tie together lines of unequal sizes. You can even use the knot as a temporary boarding ladder. Tie a bowline, lower it over the side, and tie the standing part to a cleat on the opposite side of the boat. The loop can serve as a step to re-board the boat. If you use a bowline to tie a line to an anchor, consider using a thimble to prevent chafing.

To tie a bowline, first make a small overhand loop in the standing part of the line as in figure 9-23. Leave enough line at the working end to form a loop of the size you desire. Next, pass the working end up through the small loop, around the standing part, and back down through the small loop. Pull the knot tight. The knot is usually tied with the working end inside the loop.

SPLICES

As already stated, a back splice at the end of a line can keep it from fraying. You can also use splices to tie two pieces of line together or to form a permanent loop, called an eye, at the end of a line.

You can buy mooring lines that have back and **EYE SPLICES**. Sail makers or marine equipment suppliers usually sell sheets or halyards with custom splices. However, many boating enthusiasts find pleasure in splicing their own lines. In the past, the ability to do it was seen as a sign of competent seamanship.

You can splice any fiber line. Splicing laid line is a simple process. Splicing double-braided line is a much more difficult process but it can be done.

To put an eye splice in a single braided line, you insert a tapered, pointed tool called a **FID** or a marlinspike into the line to separate the braids. You then insert the working end of the line and push it into itself about 10 to 12 inches. When you put tension on the line, it contracts like a Chinese finger puzzle. This holds the working end firmly.

Short Splice

You can join two pieces of line of the same size with a **SHORT SPLICE**. Unfortunately, the splice increases the diameter of the line. If you plan to run the line through a block after you have spliced it, use a **LONG SPLICE** to join the lines. A long splice does not increase the diameter of the line. The making of a long splice is not a part of this course.

To practice making a short splice, equip yourself with some laid manila line about 3/8 to 1/2 inch in diameter. Manila is stiffer than nylon or Dacron and holds its construction better during splicing. As you become more skillful, try splicing with polypropylene and then with nylon and Dacron.

You will need some tape or small stuff to help you splice the lines. Any kind will do since you will use it only until you complete the splice. You will also need a fid or a marlinspike.

Lash or whip both lines with tape or small stuff about twelve diameters from their ends. If your lines are 1/2 inch in diameter, this means you will whip them about six inches from their ends. Now, unlay the lines to the tapes. Then lash the ends of the strands to keep them from untwisting as you make the splice.

"Marry" the two unlayed ends. You do this by alternating the strands of one rope with the strands of the other. Following this, lash the strands of one line with tape or small stuff, as in figure 9-24A. This leaves strands "a," "b," and "c" free to begin the splice.

Take strand "a" (fig. 9-24B) and lead it over the strand on the other line that is next to it. Open a space between the strands of the other line, using your fid or marlinspike, and push the strand through it. It should look like figure 9-24C.

Roll the line toward you as in figure 9-24D. Pick up strand "b," cross it over the strand which is next to it on the other line, and tuck it under. Repeat the operation with the remaining strand and pull the tucked strands tight one by one.

When you have done all three strands, you have completed one tuck. If you are using natural fiber rope, make two more tucks. If you are using nylon or Dacron, make four or five more tucks. You have now finished one side of the splice and your splice should look like figure 9-24E.

Remove the lash from the second line. Now, do the same things with these strands that you did with the first line. When you have done this, your splice should look like figure 9-24F.

When you are done, cut off the ends of the strands to within about 1/4 inch of the main line. Roll the completed splice between your hands or under your foot. With practice, you can do the splice quickly and neatly. One way to make a synthetic rope splice tight is by placing it in boiling water. This makes the rope shrink.

Eye Splice

You make an eye splice like a short splice (see fig. 9-25). The tucks, though, are made back into the standing part of the same rope on which you are making the eye. The only tucks you make are on the working end of the line.

To make an eye splice, unlay and tape the end of the line as before. Now, form the eye to the size you want and lay the unlayed end along the standing part. Make the size of the eye just large enough to pull it over a cleat one

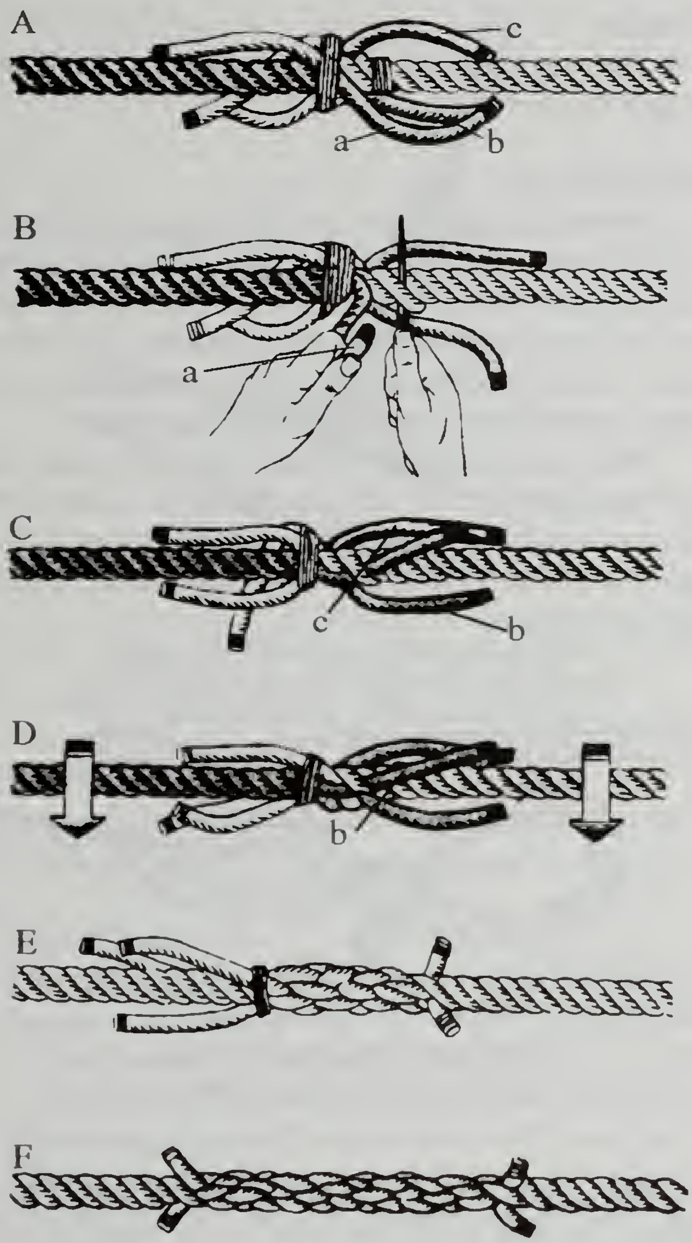


Fig. 9-24. Making a Short Splice

arm at a time. If you are sizing it for a horn cleat with an open base, make it large enough to go through the base and then over the arms one at a time.

Open the strands of the standing part and tuck the middle strand under a strand of the standing part. Next, take an adjacent strand and pass it over the strand you tucked the first strand under. Tuck it under the next strand of the standing part. Finally, turn the whole splice over and tuck the last strand under the remaining strand on the standing part. Pull the tucks tight.

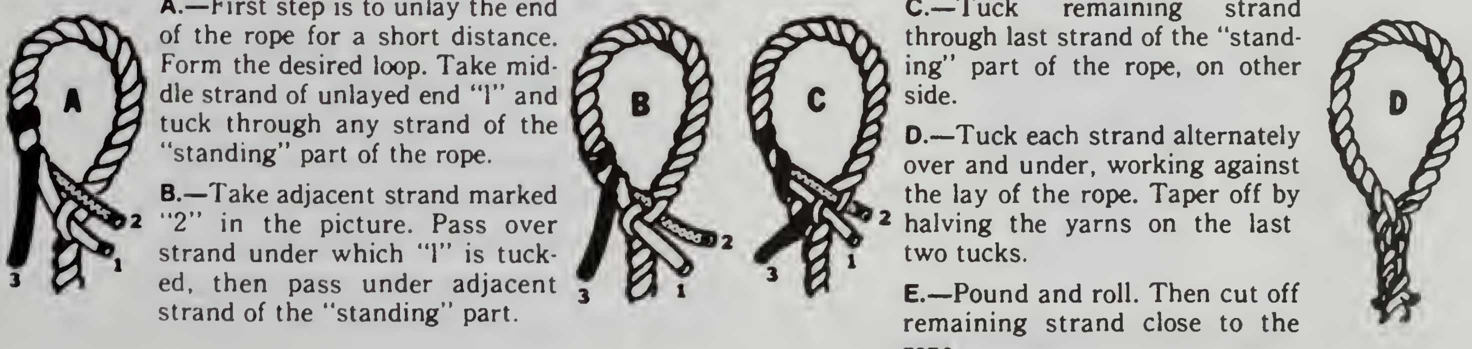
Continue with the next sets of tucks in the same manner. Use three sets of tucks on natural fiber rope and five on synthetic fiber. Taper off by cutting off half of the yarns on the last two tucks. Cut the strands about 1/4 inch from the standing part. When you have finished, pound and roll the splice to even it out.

You can use an eye splice to tie your anchor line to a thimble. As discussed earlier, you can connect the thimble to the anchor ring by a shackle.

Splicing Double-Braided and Wire Rope

You can also make eye splices in double-braided line. This is done by substituting core for core and cover for cover. This splice is not part of this course. There is a good discussion of the technique in *Chapman: Piloting, Seamanship, and Small Boat Handling.*

You can make eye splices and line to line splices in wire rope. The techniques are similar to those for splicing laid line. It is wise to leave the splicing of wire rope to professionals.



A.—First step is to unlay the end of the rope for a short distance. Form the desired loop. Take middle strand of unlayed end "1" and tuck through any strand of the "standing" part of the rope.

B.—Take adjacent strand marked "2" in the picture. Pass over strand under which "1" is tucked, then pass under adjacent strand of the "standing" part.

C.—Tuck remaining strand through last strand of the "standing" part of the rope, on other side.

D.—Tuck each strand alternately over and under, working against the lay of the rope. Taper off by halving the yarns on the last two tucks.

E.—Pound and roll. Then cut off remaining strand close to the rope.

Fig. 9-25. Making an Eye Splice

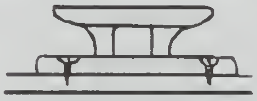
SECURING LINES

There are many special fittings for securing lines. You use them both on boats and piers. There are fewer special fittings on power boats than on sailboats.

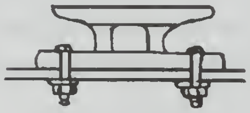
Through-Bolt Your Fittings

Hardware for securing lines on a boat is attached to the hull or the spars. From time to time these fittings are subject to considerable stress. For this reason, fittings should be bolted through the deck or gunwales rather than just screwed to them.

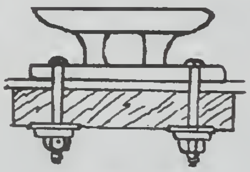
On all but the smallest boats, the bolts should go through a backing plate to make a fitting secure. If you have a cleat on a gunwale, glue or otherwise attach a metal plate or a piece of 3/4 inch marine plywood under the gunwale. Now, drill holes through the gunwale and the plate and fill them with marine caulking before bolts are inserted in them. (The caulking prevents water from entering and damaging the inner layers of the gunwale.) Secure the bolts of the fitting with appropriate nuts and washers. It's worth the effort. If a fitting comes loose under severe stress, it can be dangerous. It is also easier to through-bolt a fitting than to patch a deck after a fitting has pulled loose.



Avoid Wood Screws



Bolt Thru Is Better



Bolt Thru With
Wood Block Is
Recommended

Fig. 9-26. A Through-Bolted Cleat

Cleats

There are several types of cleats. Each serves a specific purpose.

Horn Cleats

HORN CLEATS are anvil-shaped fittings. Their bases may be either open or closed. You tie anchor rodes, mooring and docking lines, sheets, and halyards to them. Cleats are the most common fittings for lines on small boats. Horn cleats are also called mooring cleats.

One way to secure a line to a horn cleat is by **BELAYING** it. To do so, take one complete turn around the cleat. Do not make more than one complete turn as the line may jam on itself under tension.

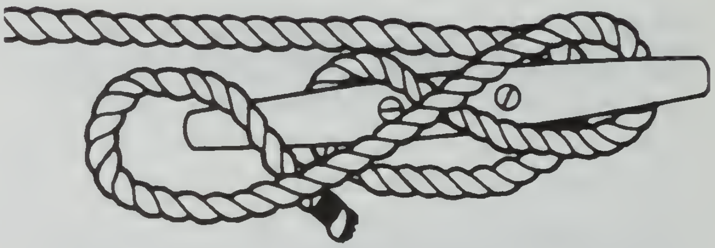


Fig 9-27. Belaying a Cleat
(Note the Weather Hitch)

After you take a full turn around the cleat, lead the line over the cleat and around its horns to form a figure eight. Make two or more eights and pull the line tight. This way of belaying permits you to take the line off the cleat rapidly.

When you belay to a horn cleat and leave your boat unattended, the connection needs to be more secure. To do this, make only one figure eight and finish off with an underhand loop over one of the horns. This hitch is a **WEATHER HITCH**. In making the weather hitch, be sure to have the line continue to form a figure eight as in figure 9-27. In this way the knot develops the maximum friction.

Another way to secure a line to a horn or mooring cleat can be used when the cleat has an open base and the line has an eye splice. Push the splice through the open base, as in

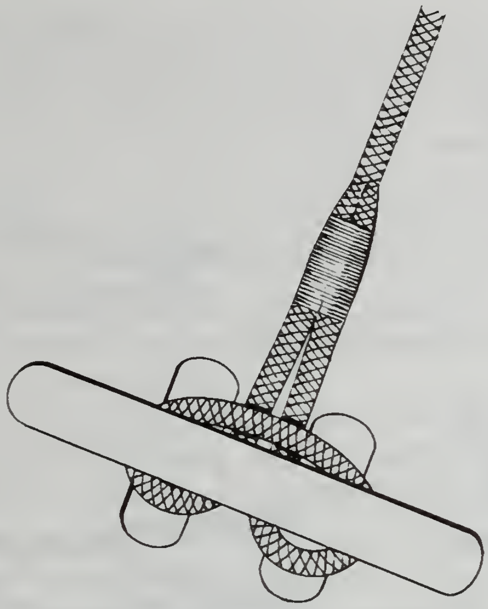


Fig 9-28. Securing a Line to a Horn or Mooring Cleat (Notice the Whipping on the Eye Splice to Make It Secure.)

figure 9-28, and then over the horns one at a time.

Jam Cleats

A **JAM CLEAT** is similar to a horn cleat but there is one important difference. One of the horns forms a tapered slot into which the line is "jammed." This allows you to secure and to release a line quickly since you need less than a full turn to hold it.

Jam cleats usually secure sheets on sailboats. Sometimes they are used to secure a centerboard pendant to control its position or depth.

You must install a jam cleat so the tapered slot is in the same direction as the standing part of the line. Thus, when you first lead the line around the base of the cleat, it will not bind. Turning it around the other end binds and holds the line. A jam cleat accommodates only one line size. If you use either a larger or smaller line than that for which it is sized, it will not function properly.

Cam Cleats

A **CAM CLEAT** has two moving, serrated cam-shaped jaws for holding a line. The jaws are spring-loaded and rotate open to release the line when you pull it. When the standing part of the line pulls against the cleat, it tightens.

In use, you place the line over the teeth and pull it through and down to open it. You can tighten the line simply by pulling it in. To ease or release it, you must first pull the line and lift it out of the jaws.

Cam cleats are suited only for small sailboats. You must install them in the correct direction since they work only one way. Cam cleats can be hard to release when there is a heavy load on the line such as during a high wind. Unfortunately, this may be the time you may most want to let the line go quickly.

Turnbuckles

A **TURNBUCKLE** is a threaded fitting that pulls two eyes together as in figure 9-31. On sailboats, you use turnbuckles on wire rigging

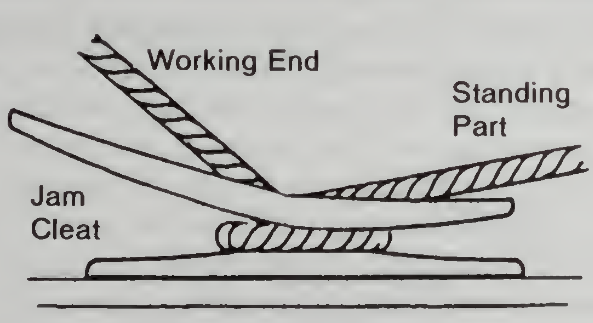


Fig. 9-29. A Jam Cleat

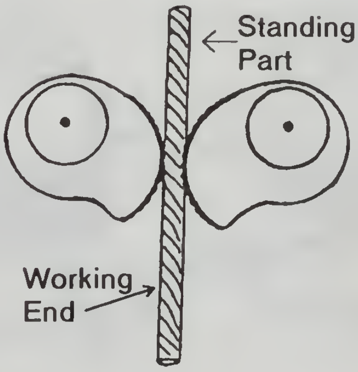


Fig. 9-30. A Cam Cleat

that supports the mast. They have threads so you can put the proper amount of tension on the shroud or stay. There are several ways to lock turnbuckles to keep them from working loose after they have been adjusted.

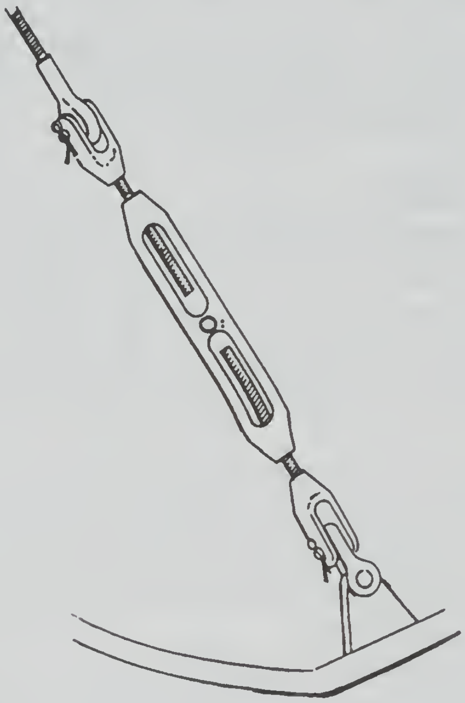


Fig. 9-31. A Turnbuckle

Samson Posts

Larger boats have **SAMSON POSTS** instead of cleats for anchoring or mooring. A samson post is a column of wood or metal with a pin or bar through it near the top. To secure a line to the post, first take several turns around its base. Then finish with an underhand loop on each pin as if you were securing to a cleat.

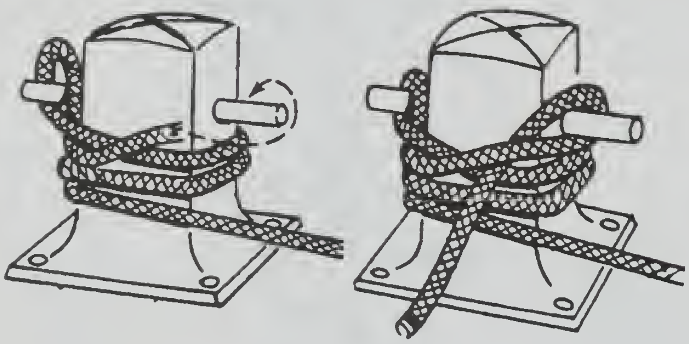


Fig. 9-32. Samson Posts

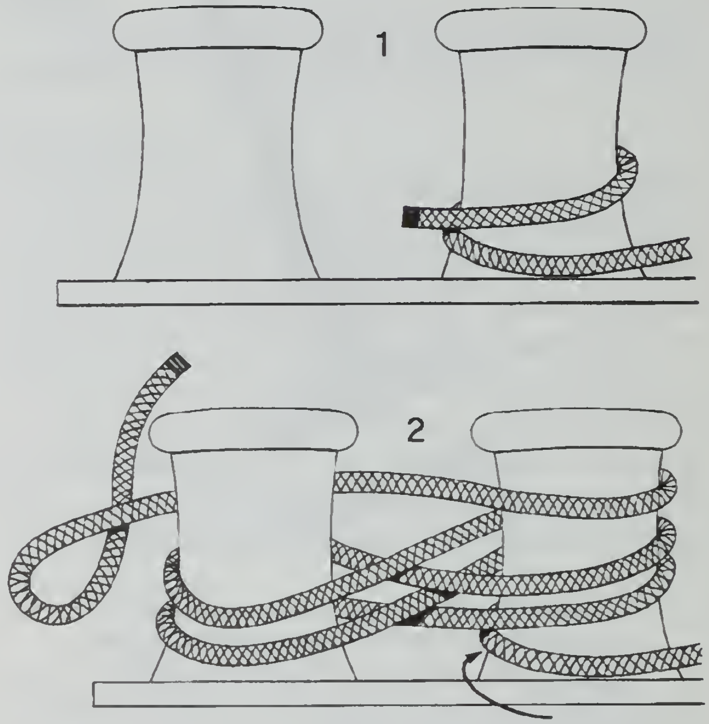


Fig. 9-33. Bow Bitts

Bow Bitts

Large boats may have **BOW BITTS** instead of samson posts or cleats. Bow bitts are a pair of circular metal columns on a common base. Each column usually has a lip around its top. To secure a line, take a complete turn around the bitt or post nearest the standing part of the line. Finish the hitch by making a series of figure eights around the bitts.

Chocks

You usually lead lines from cleats, samson posts, and bitts through "U" shaped fittings called **CHOCKS**. They limit the direction of the pull on a cleat, help prevent chafing of the line, and prevent the line from damaging the boat. Lines passing through chocks often have chafing gear to further reduce chafing.

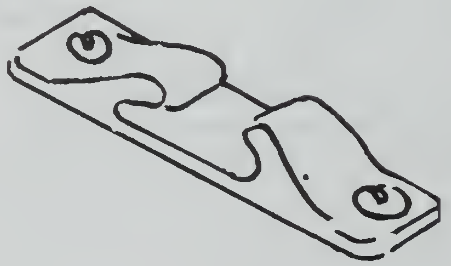


Fig. 9-34. Chocks Protect Both Line and Boat.

Other Hardware Items

A **WINCH** helps pull in a loaded line such as an anchor rode. It consists of a metal drum with a series of gears inside, fastened to a secure base. An anchor winch, called a **WINDLASS**, may have an electric motor. A winch on a trailer may also be electric. This winch helps you load your boat onto the trailer. Sailboat winches tighten sheets. You turn them manually with a handle.

Drums of winches on sailboats rotate clockwise as viewed from the top end of the drum. Thus, you must wrap the line clockwise around the drum for the winch to work. The number of wraps depends on the load on the line since the winch does its work through friction. Four turns are usually the most required for synthetic line. Wire rope may require six turns.

Some sailboat winches provide two gear ranges to afford more pulling power. Turning the handle clockwise on these winches provides normal power. Turning the handle counterclockwise changes gears and increases the pulling capability. The drum turns in a clockwise direction in either mode.

On a large sailboat you may need two people to operate a winch. One person cranks the winch while the second collects the tail (working) end of the line as it comes off. The second person also secures the line to a cleat after you have the sail properly trimmed.

SELF-TAILING WINCHES solve the problem of two people working in a confined space. The top of the drum contains a notched channel that holds the line as it feeds off the drum. On a self-tailing winch, the notched channel also acts as a cleat to hold the line.

Lead Lines

A line weighted with lead is sometimes used to measure the depth of water. This lead line usually has at least five pounds of lead, and can measure depths up to 100 feet. Braided cotton line makes the best lead line. It should be 150 to 200 feet long since you throw it out ahead of the boat.

You mark the line in a standard pattern by strips of tape or leather or by knots. These tell the depth of the water. Plastic strips with large numbers are available and easily attached to the line. They are difficult to read in the dark so many mariners prefer markings that you can read by feel.

In use, you cast the lead forward with an underhand swing while the boat is going forward slowly. The speed must be slow enough that the lead reaches the bottom by the time the line stands vertically. Subtract the vertical distance from the hand of the person casting the lead to the water from the length of the line paid out to get the water's depth.

It was from a lead line that Samuel Clemens got his pen name of Mark Twain. It comes from a Mississippi riverboat sounding "by the mark, twain" or two fathoms (12 feet).

Some leads have hollowed-out portions in their bottoms. You fill them with a sticky material such as tallow or bedding compound. This material collects a small sample of the bottom. Your chart usually shows the character of the bottom. The sample may help you confirm your position. It can also help you know when the bottom is good for anchoring.

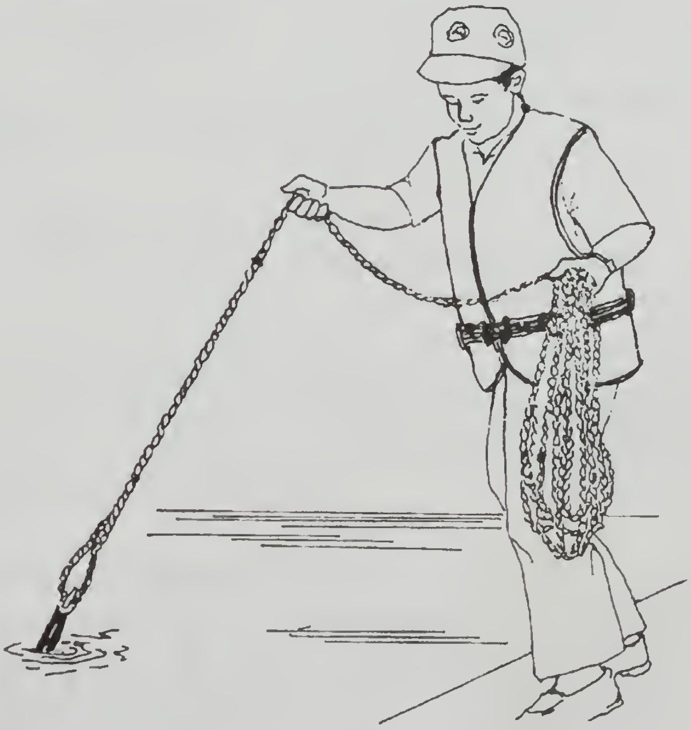


Fig. 9-35. Sounding with a Lead Line

DIPPING THE EYE

At times you must put the eye of your mooring line over a piling on which there is already a line. It is poor etiquette to place your line on top of one that is already there. It may also be dangerous. Your line may be removed so the other boat can be untied. If the other boater is in a hurry, your line may not be returned to the piling.

To avoid the problem and to be courteous, **DIP THE EYE** of your line. Bring the eye of your line up through the eye of the first line and then drop it over the piling. The other line can then be removed first. If you were to leave first, reverse the process. In this way you can free your line without removing the other line.

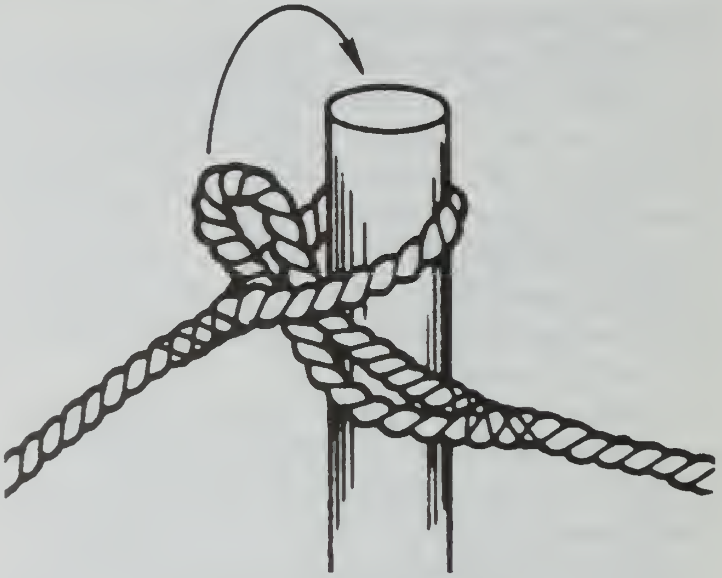


Fig. 9-36. Dipping the Eye

10

Weather and Boating

Boaters have a special need to know about **WEATHER.** On land, the effects of storms can be devastating. At sea, they can be even worse. High winds, lightning, rough seas, and poor visibility are some of the things that accompany storms. Your recreational outing can end in disaster. But it need not.

The first step in avoiding weather problems is, "Know before you go." If bad weather is in the offing, don't go. This means that you need to know where to get good weather information before you go out on the water. This chapter starts by telling you where you can get it.

At least as important as knowing what weather to expect on your trip is knowing how to tell when the weather is changing. Is the weather what you expected? Are there signs that it is changing? This is the second aspect of this chapter. To help you answer the question, we will discuss the causes of weather.

Finally, we want to give you some information that will help you if you are caught out on the water in bad weather. This is the third aspect of the chapter.

SOURCES OF WEATHER INFORMATION

There are many sources of weather information near at hand. Some of these are excellent. Others may serve boaters poorly.

Broadcast and Newspaper Forecasts

Commercial radio and television stations and newspapers give weather reports. The information they give is important but it may not be what you need as a boater. They seldom focus on marine weather.

Radio, television, and newspaper forecasts usually cover wide areas such as a state, a multi-state area, or the nation. Thus, they lack the detail you need for where you will boat. Their information may also be out-of-date when you receive it. Have you ever listened to a forecast of a beautiful, clear day, looked out the window, and seen that it was raining?

Commercial radio stations that repeat current broadcasts of the National Weather Service (NWS) are an exception. However, they may not be available when you need them. They, too, can be out-of-date.

Telephone Information

In some locales, principally large metropolitan areas, recorded telephone marine weather forecasts are available. If you use them, call while you are planning your cruise. Then call again just before you leave to get the latest update. Check with the service to see how often it updates its forecasts.

National Weather Service

The National Weather Service continuously broadcasts weather information over its network of FM weather stations. Its forecasts focus on specific locales and give marine weather conditions where applicable. NWS updates its forecasts as soon as new information is available. If severe weather develops, NWS immediately broadcasts the information.

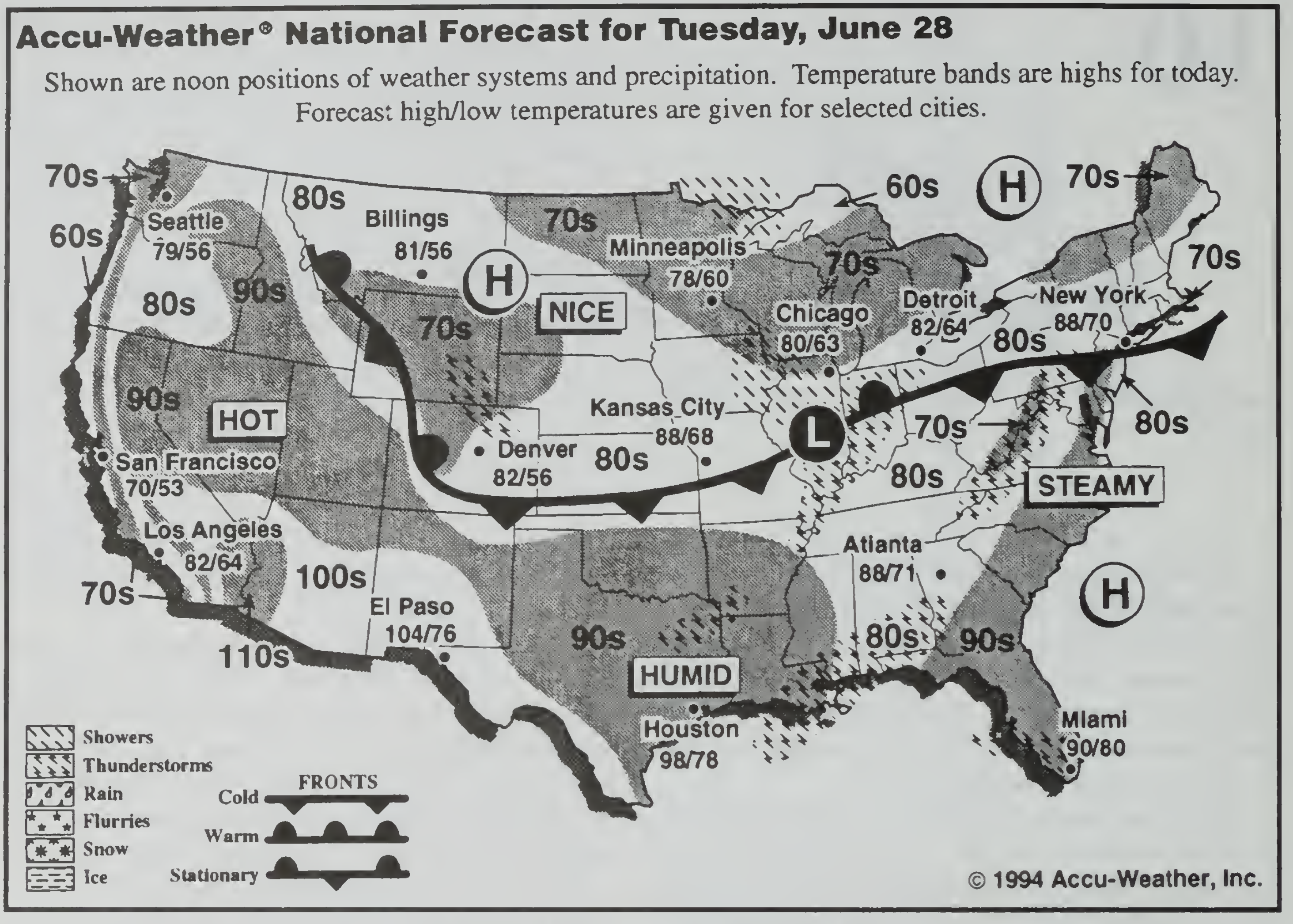


Fig. 10-1. A Newspaper Weather Map
(Courtesy of Accu-Weather, Inc.)

You can receive NWS broadcasts on inexpensive, narrow-band, FM receiving sets. These sets use either household electrical current or batteries. The broadcasts are also available on the weather channels of your VHF-FM marine radio. You should be able to receive NWS broadcasts on one or more of their broadcasting frequencies. If you have a VHF-FM radio or a narrow-band receiving set aboard your vessel, you can receive the latest information while you cruise.

Fig. 10-2. A VHF-FM Radio, Use it to Receive Weather Information.
(Photo Courtesy Shakespeare, Electronics & Fiberglass Division)

Other Information Sources

For those who cruise long distances and for commercial shipping interests, other sources of information are available. Coded weather data are broadcast by short wave radio, and facsimile weather maps are available from shortwave broadcasts.

You can detect an electrical storm by static on an AM radio tuned to a broadcast station. You can detect a storm even if it is so far away that you can't see or hear it. Static is an irritation for land lubbers but a timely warning for mariners.

Pennants, Flags, and Lights

In the past, yacht clubs, marinas, and Coast Guard facilities showed special weather pennants, flags, and lights to warn mariners of bad weather. Today, few places display these warnings. Better sources of information have made them obsolete. The Coast Guard is phasing them out. Stations will continue to display them as desired by their commanders but only until the stock of pennants is gone.

A red pennant in the daytime or a red light over a white light at night warns of winds as high as 33 knots or dangerous sea conditions. This is a **SMALL CRAFT WARNING**. Two red pennants in the daytime and a white light above a red light at night are **GALE WARNINGS**. Winds of 34 to 47 knots are forecast.

A red flag with a black center in the daytime and two red lights at night is a **STORM WARNING**. Winds of 48 knots and above are forecast. Two square, red flags with black centers in the daytime and a white light between two vertical red lights at night warn of a **HURRICANE**. Winds of 64 knots and above are forecast.

WIND AND BOATING

Fog, heavy rain, sleet, and snow create problems for boaters by reducing their visibility. In reduced visibility, you may become disoriented and unable to return to port. You become more vulnerable to collisions and to grounding. Although these problems are serious, they are mild in comparison with those created by wind.

Wind is a basic problem in thunderstorms, tornadoes, waterspouts, tropical storms, gales, hurricanes and other extreme weather conditions. But wind does not have to be this strong to create dangerous boating problems. Even fairly mild winds can create rough boating conditions by their effects on water.

Wind is also an indirect cause of many marine and boating problems. Strong winds pile up water in front of them. Hurricane force winds pile up even more water. The storm "surge" caused by a hurricane may raise the sea level as much as 18 to 20 feet. This is in addition to a "normal" high tide and the wind driven waves on top of the surge. Hurricane surges may extend for hundreds of miles.

Winds do not have to be of hurricane force to create a surge. Most northeast storms along the north Atlantic coast create surges and cause severe property and ecological damage. In strong winds, the water levels of bays and sounds rise beyond those of normal tides. Moored boats may rise as far as their mooring lines will permit and will sink if the water rises farther. Moored boats may rise above the pilings to which they are tied and be impaled on them as the water level falls. Boats in covered slips may be crushed against the roofs.

WIND AND WAVES

The most common wind related problem faced by boaters is rough water. Large waves may overturn or swamp small boats. As you have already learned, breaking waves can make small boats yaw and broach or pitchpole.

Most waves are caused by wind and continue to grow from it. Up to a point, the longer the wind blows, the higher the waves become. Too, the greater the uninterrupted expanse, or **FETCH**, over which the wind blows, the higher the waves. Eventually, the waves reach a maximum height for the fetch, wind speed, and duration of the wind.

Swells

SWELLS are waves that have traveled a long way from their source. As they travel, their heights decrease and the distance between them increases. Even large swells do not present problems for boaters.

Breaking Waves

As waves approach shore, they begin to drag on the bottom. This slows the speed of the wave's bottom. In turn, the slowing causes the water to pile up. As a result, the waves crest and may break. A series of breakers is a surf. How should you handle your boat in surf? The best advice is, "Stay away from breaking surf. It's dangerous."

Wave Height

A weather prediction of, "Seas three to five feet" means that 70 percent of the waves are expected to be between three and five feet high. Fifteen percent will be less than three feet high and 15 percent will be more than five feet. Be prepared for the occasional wave that may be seven or more feet high. Never anchor from the stern of your boat. Your boat may be swamped by an "occasional" wave or severe wake. It can happen in fairly calm seas.

In large bays, lakes, sounds, and at times in coastal areas, wave heights can change abruptly with a change in weather. Waves can go from two to four feet to six to ten feet in just a few minutes.

Waves in Shallow Water

Besides differing from wind speed, wind duration, and fetch, waves differ according to water depth. Wind over shallow water, such as in Lake Erie and Albemarle and Pamlico Sounds, generates steep waves that are close together. Two to four foot waves in shallow water present serious hazards for small boats. Over deep water, the waves have more gradual slopes and are farther apart.

UNDERSTANDING WEATHER

The knowledge that wind causes waves, begs the question, "What causes wind?" To answer this question, you need to understand a few things about weather.

There is also another reason you need to know something about weather. You have learned how to get good weather information. Now you need to be able to answer the question, "Does what I see mean the weather is changing?" If it is, you may want to change your plans. If you are on the water, you may wish to seek shelter.

Knowing something about weather can help you avoid some of its perils such as high winds, thunderstorms, lightning, heavy rain, fog, and other hazards to boating. It can also help you anticipate and know how to react to conditions such as squall lines, microbursts, and windshear.

WEATHER AND HEAT

Heat from the sun causes wind and weather. It does so by warming the air. There are two basic facts; warm air is lighter than cold air, and warm air can hold more moisture than cold air. Because of this, warm air rises. Likewise, if you cool warm, moist air, it must lose some of its moisture.

Heat and Air Pressure

When land or water is heated or cooled, the air above them is heated or cooled. Air expands and becomes less dense when warmed. This makes it lighter so it rises. As a result, air pressure is lower in the area from which the air is rising.

Cooler air from surrounding areas flows into the low pressure area caused by the rising air. Like water, air always flows from high pressure areas toward low pressure areas. This moving air is wind. The greater the difference in pressure between the warm and cool air areas, the stronger is the wind. So, heat causes wind.

Land and Sea Breezes

Unequal heating of land and water causes land or sea breezes. During the daytime, land heats more rapidly than water. Thus, air rises over the land, and the air over the water flows in to take its place. This is a "sea breeze." At night, the land loses heat more rapidly than the water. The ocean water may be warmer than the land. If so, the air movement reverses direction. This is a "land breeze." This diurnal movement of air is often conducive to the formation of fog.

Heat and Temperature Changes

Other factors affect the amount of temperature rise or fall with equal amounts of heat gain or loss. Large, deep bodies of water lessen temperature change while continents favor large change. Thick vegetation or swampy land lessens temperature change. Arid, barren surfaces permit the greatest temperature change. The air above each of them is heated to different degrees. Among other things, this causes differences in air pressure, amounts of moisture in the air, and the strength of the wind.

Global Air Circulation

Some movements of air are global in nature (see fig. 10-3). Heat from the sun warms the ground and ocean near the equator. This warms the air above the equator, which then rises creating an area of low air pressure. Cooler, heavier air from regions north and south of the equator flows in. The air is flowing from a

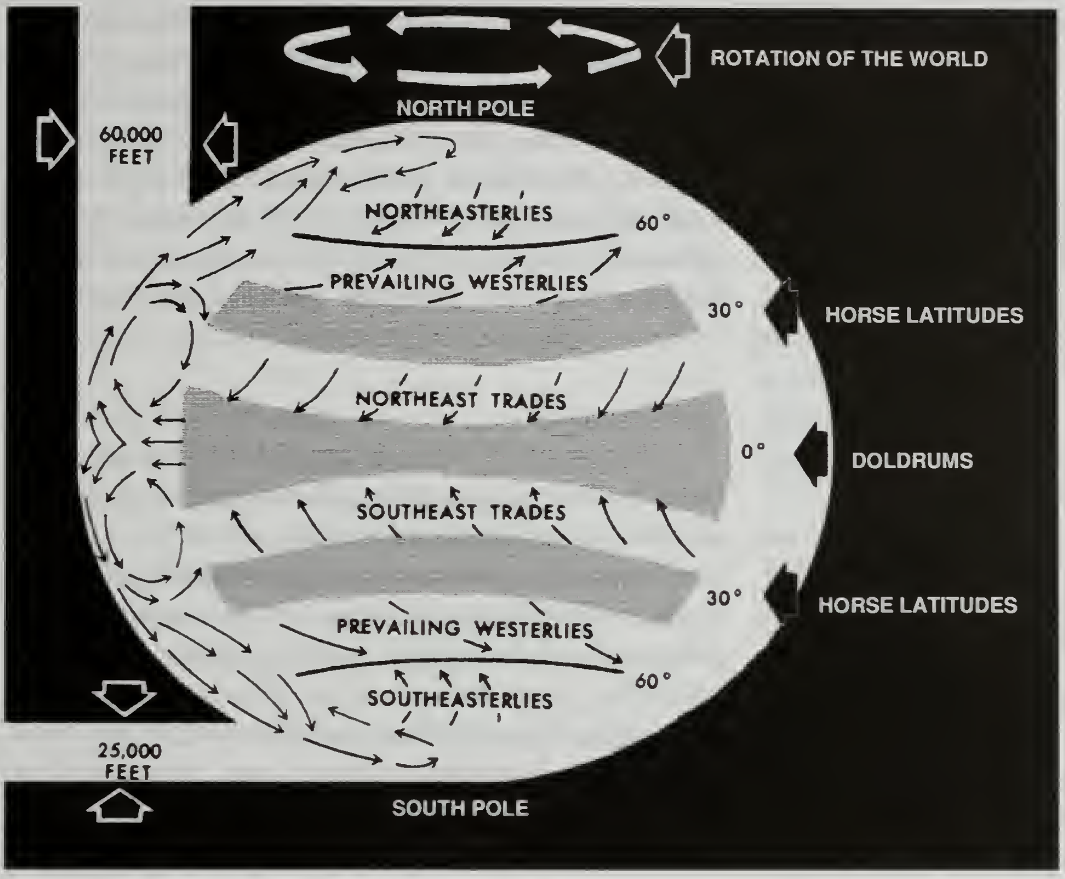


Fig. 10-3. Global Atmospheric Circulation

region of high pressure to one of low pressure.

The rising air near the equator causes a large band of low air pressure. This is a band of calm air with frequent squalls and light, baffling winds called the **DOLDRUMS**. It is an area of low pressure since its heated air rises more rapidly than cooler air can flow in to take its place.

As the heated air rises, it flows north and south away from the equator and toward the earth's poles. When air rises, it expands. As a result, it loses some of its energy and it cools. It also cools since it radiates some of its energy into space.

Some of the cooler air, while still moving northward, settles back to the earth and meets the air mass moving toward the equator. These two movements tend to cancel each other. As a result they form bands of calm air.

One of these bands is at 30° N latitude, the latitude of St. Augustine, Florida. As you can see from figure 10-3, air tends to flow north and south away from the band. Thus, a band of calm, light air is formed.

Most of the United States lies north of 30° N latitude. In it, the winds are westerlies. They are called the prevailing westerlies since they move from west to east except during storms and other exceptional conditions. Global air movements also cause other prevailing winds and bands of air pressure.

The Coriolis Force

The **CORIOLIS FORCE** affects anything that moves over the earth's surface, through the air, or through water. It affects flying birds, missiles, aircraft, ocean and air currents, and submarines. Although the path of something through space may be a straight line, on the earth's surface it curves. In the northern hemisphere, the path over the earth's surface turns to the right. In the southern hemisphere, it turns to the left.

The Coriolis force acting on moving air is responsible for the prevailing winds in the belts formed by the circulation of air from the equator. Thus, south of 30° north latitude, the prevailing winds are the northeast trade winds. Above 30° north latitude, the winds blow mainly from the west and are westerlies. Above 60°

north latitude, the prevailing winds are from the northeast. Storms and other transitory conditions change these patterns.

Columbus and Wind Patterns

Columbus took advantage of the northeast trade winds and the prevailing westerlies when he came to the "new world." His square-rigged sailboats were best at sailing before the wind. He sailed down the coast of Africa to the belt of the northeast trade winds. Then he turned west. No wonder his crews were upset. Day after day the wind blew from astern. How were they going to get home?

But Columbus understood the circulation belts of the earth. When he left the West Indies, he sailed north until he came to the prevailing westerlies. He then sailed east. Is it any wonder that St. Augustine became a replenishing port for food and water for Spanish ships returning from the new world? It is on the Florida coast at 29° 53' north latitude, seven nautical miles south of 30° north latitude.

Temperature and Humidity

One more factor is necessary to explain weather. As has already been stated, warm air can hold more moisture than cool air. You see the result of this on a summer day when you mix up a cooling drink. The glass cools the warm, moist air that contacts it. The air can't hold as much moisture as when it was warmer and some of it condenses on the glass.

The temperature at which moisture begins to condense on the glass is the **DEW POINT**. The more moisture the air contains, the more **HUMID** it is. If there is no change in temperature, the more humid the air, the higher its dew point. In other words, moisture condenses out of very humid air when the temperature is lowered only slightly.

Contrary to popular belief, moist air is lighter than dry air. Warm, moist air is even lighter. Since it is, it rises rapidly. Cold, dry air descends. Warm air is said to be more unstable than cold, dry air.

Moisture and Energy

It takes enormous amounts of energy to change water from a liquid to a vapor. When water vapor condenses back to a liquid, this energy is released. When you heat water, it takes relatively little heat to raise its temperature to the boiling point. It takes many more times that amount of heat to change it into steam. When the steam changes back into a liquid, the heat is released. This is why steam burns flesh so badly. It also accounts for the violence of some storms. In a storm the moisture in the air changes back to a liquid and releases its pent-up energy.

Air Masses

The global circulation of air creates air masses. Air masses also form from differences in heat over land and water.

These air masses move over the earth's surface and determine much of our weather. As they move they tend to keep their moisture, pressure, and temperature characteristics. As we might expect, the masses with high pressure, called **HIGHS**, contain cool, dry air. Low pressure areas, or **LOWS**, have warm, moist air. In the continental United States, these air masses move mainly from west to east.

Air Flows from Highs to Lows

Air flows out of high pressure areas. As it does, the Coriolis force turns the flow to the right in the Northern hemisphere. Since the air flows from the center and all sides of a high, the Coriolis force gives the air in a high a clockwise movement.

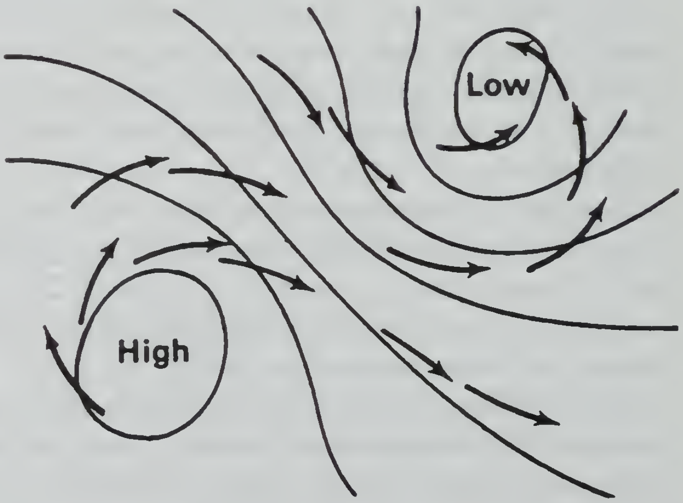


Fig. 10-4. Air Circulation--Clockwise around Highs, Counterclockwise Around Lows in the Northern Hemisphere

Air from a high flows toward a low. As it does, it turns to the right. Thus, air around and in a low moves in a counterclockwise direction. The Coriolis force gives it its direction of rotation. It also causes the low to keep its characteristics. Since the Coriolis force turns the air flow away from the center of the low, the high pressure cannot readily neutralize the low. Figure 10-4 shows the movement of air in and around high and low pressure areas.

Buys-Ballot's Law

It is useful to know where the high and low pressure areas are in relation to you. Lows are a source of bad boating weather. Highs that are moving toward them may have strong winds that create waves and bad boating conditions. The area between the high and the low may have stormy weather.

To locate the highs and lows in the northern hemisphere, stand with your back to the surface wind. Now turn 45° to your right. This aligns you with the wind aloft. It always blows in this direction unless the surface wind is affected by local conditions such as buildings. After you have turned 45° to your right, the low is normally to your left. The high is to your right. The pressure area to the west is usually the one that will reach you. The one to the east has already passed. If low pressure is to the west, weather conditions may deteriorate.

Fronts

As air masses move out of their source regions, they meet air masses with different properties. The zone between two different air masses is a **FRONTAL ZONE** or **FRONT**. Across this zone, temperature, humidity, air pressure, and wind often change abruptly over a short distance. Fronts are the sites of most large-scale weather conditions such as winter rain storms, sleet, and snow. They are also the source of many boating problems.

Types of Fronts

Fronts are named for the type of air that is *arriving*. When a mass of cold air catches up with a mass of warmer air, a **COLD FRONT** forms. If the overtaking air mass has warmer air in it than the overtaken mass, the front is a **WARM FRONT**. When neither air mass is overtaking the other, the front is **STATIONARY**.

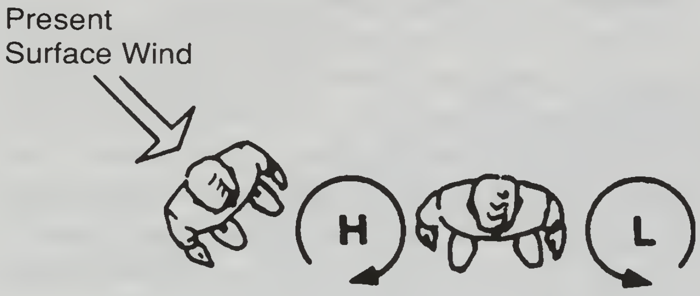


Fig. 10-5. Buys-Ballot's Law for Determining Location of Low Pressure Area

A cold air mass may approach a warm air mass and form a cold front. If the cold air mass then slows to a stop, a stationary front forms. If the cold air mass then moves back toward where it came from, a warm front forms. The air behind a warm front is warmer than the air ahead of it.

On a weather map, commonly recognized symbols designate each of these three fronts (see fig. 10-1). A heavy line with pointed barbs on the advancing side represents a cold front. A warm front has a heavy line with rounded barbs on its advancing edge. A stationary front has alternate rounded and pointed barbs. The pointed barbs point toward the warm air. The rounded barbs point toward the cold air.

If the map is in color, such as on TV, cold fronts are blue. Warm fronts are red, and stationary fronts have blue and red segments.

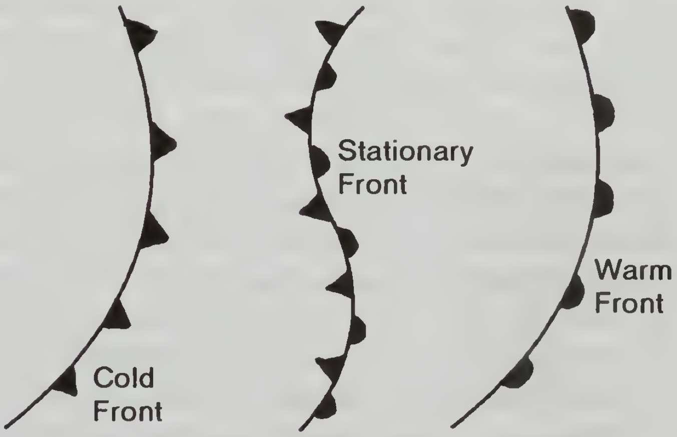


Fig. 10-6. Representation of Fronts on Weather Maps

Changes as Fronts Pass

When a front passes, there are noticeable changes in air properties. If the overtaking air mass is moving rapidly, the zone between the air masses is narrow and the changes are abrupt. If the zone is wide and diffuse, the changes are more gradual. When the change is abrupt, the weather is more violent.

Temperature Differences. As a front passes, there are changes in temperature. These changes are usually very noticeable. The air behind a cold front is always colder than the air in front of it. In a warm front, the overtaking air is warmer than the air it is overtaking.

Moisture. The moisture content of air in the two masses is usually significantly different. Behind a cold front the air is drier than the air in the overtaken mass. The air behind a warm front has more moisture than the air in front of it. When a cold front passes in the winter, you expect clear, cold, dry air to follow. Ahead of it, you expect rain or sleet. You expect moist air and probably fog when a warm front passes. Ahead of it may be snow, rain, or fog. All of these conditions have implications for boating.

Wind. Wind always changes across a front. The change may be in direction or in speed or in both. The wind shift as a front passes is almost always clockwise. For example, if it is blowing from the southwest before the front passes, it will change to northwest after it has passed. The shift is usually abrupt and higher winds occur. These may pose a danger for small craft. If you are on the water when such a shift occurs, head your vessel into the wind.

Pressure. Pressure is higher in the cold air. Thus, when a front passes bringing colder air, air pressure usually rises abruptly. When a front approaches bringing warmer air, the pressure usually falls until the front passes. It then remains steady or it may decrease slightly. The important thing to remember is that when a front passes, a change in pressure occurs. If you have a **BAROMETER** you can measure the change in air pressure.

A barometer is most useful in predicting *changes* in weather. A "falling" barometer means a low pressure area is approaching. A "rising" barometer means the low is passing and a high is approaching. All changes in barometric pressure are not significant, however, a rise or fall of .2 inch or more per hour, is usually significant and indicates changing weather. The more rapid the change in pressure, the greater is the expected change in the weather.

Cold Fronts

Cold fronts move at speeds of 10 to 30 knots, depending on the time of year. They are two to three times as fast in winter as in summer. If a cold front is moving fast, the zone between it and the warm air mass in front of it will be narrow and the changes in weather will be abrupt. Thus, if a cold front is moving fast, there will probably be a line of strong winds in front of it called a **SQUALL LINE**. Wind speeds in squall lines are often as high as 30-60 miles per hour. Gusts may be as high as 80-100 miles per hour. Squall lines present dangerous boating conditions. Behind them is heavy rain, followed by clearing.

The air behind a cold front is denser than the air in the warm mass it is overtaking. This is so because dry air is heavier than wet air. Too, cold air is heavier than warm air. As a result, the cold air wedges in under the warm moist air in the warm mass. This forces the warm air to rise.

If the air temperature difference on the two sides of the front is small, the slope of the warm air rise is gradual. The frontal area is broad and its stormy weather is not severe. If the temperature difference is large, the warm air

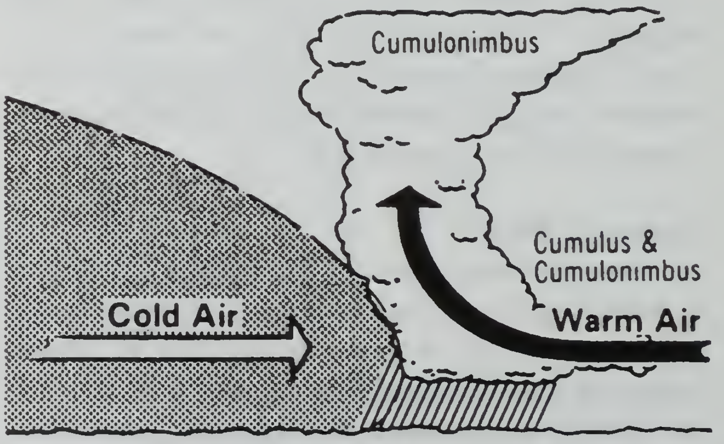


Fig. 10-7: Collision of Cold and Warm Air Masses Results in Bad Weather for Boaters.

rises rapidly (fig. 10-7). The frontal zone is narrow and the resulting weather is severe.

When the warm, moist air in the mass preceding a cold front rises, it cools. When it cools, it can no longer hold all of its moisture. Some of it condenses to form clouds. If it condenses still further, precipitation occurs. As it condenses, it releases the energy it absorbed in changing from a liquid to water vapor. This gives the storm its energy.

When a cold front passes, the abrupt shift in wind direction may create a windshear. In a windshear, strong eddies occur along the mixing zone. If the zone is very narrow, the eddies may be strong.

A vessel passing across the mixing zone is subject first to strong winds in one direction. Very shortly it meets equally strong winds blowing in the opposite direction. Windshear has caused airplane crashes. Sailboats have been dismasted by it. Powerboats may be subjected to severe yaw and may capsize.

If the difference in temperature between the two air masses is small, the precipitation is usually light. If the difference is larger, more violent storms occur. Frequently, the storms that occur are thunderstorms. Thunderstorms may have strong winds, windshear, lightning, heavy rain, hail, and sometimes tornadoes. This is not good boating weather. If a cold front is approaching, don't boat. If you are boating and a front approaches, seek safe harbor.

Warm Fronts

Warm fronts travel much slower than cold fronts. The zones between warm fronts and the cold air that precedes them are wider and more diffuse than those that precede cold fronts. Thus, the changes as warm fronts approach are more gradual and less violent.

As a warm front approaches, air pressure starts to fall steadily and winds increase. A steady rain begins to fall. The temperature begins to rise. Air pressure may rise and then fall slightly.

The air in a warm air mass is warmer and holds more moisture than the air in a cold air mass. Warm, moist air is lighter than cold, dry air. As a result, the warm, moist air rides up and over the cold air in front of it. The slope of the rise is very gradual and the frontal area may be hundreds of miles wide (see fig. 10-8). Some fog will probably form.

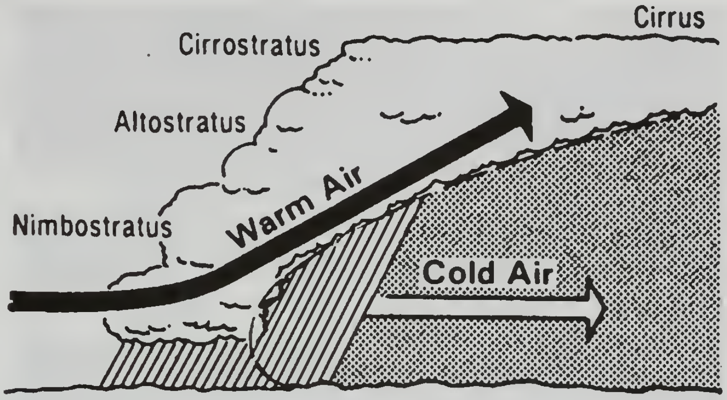


Fig 10-8. A Warm Front Storm

The rising warm, moist air cools and its moisture condenses. Since the slope of the rise is gradual, clouds are formed well in advance of any precipitation. Precipitation is gentle. Rain or snow may occur but you would not expect violent weather such as in a thunderstorm. Warm front weather seldom presents violent boating conditions. The fog which may accompany it, may be a serious problem. Be alert for its presence near a warm front.

Clouds and Fronts

Three types of clouds accompany fronts—cumulus, stratus, and cirrus. All are the result of moisture ladened air carried aloft. As the air rises, it cools and some of its moisture condenses to form a cloud. The rapidity with which the warm, moist air ascends determines the basic structure of the cloud. In general, clouds get their names from their shapes and their altitudes.

CUMULUS clouds are the fluffy, piled-up clouds often seen in summer skies (fig. 10-9). They are usually "fair weather" clouds but they can develop into towering **CUMULONIMBUS** clouds called thunderheads (fig. 10-13). **STRATUS CLOUDS** are flat and frequently layered (see fig. 10-12).

High level clouds have a prefix of cirro-. In Latin, cirro means "curl" which often describes their appearance. These clouds have altitudes of 20,000 feet and higher.

CIRRUS CLOUDS are thin, high level clouds made of ice crystals. They are often called mare's

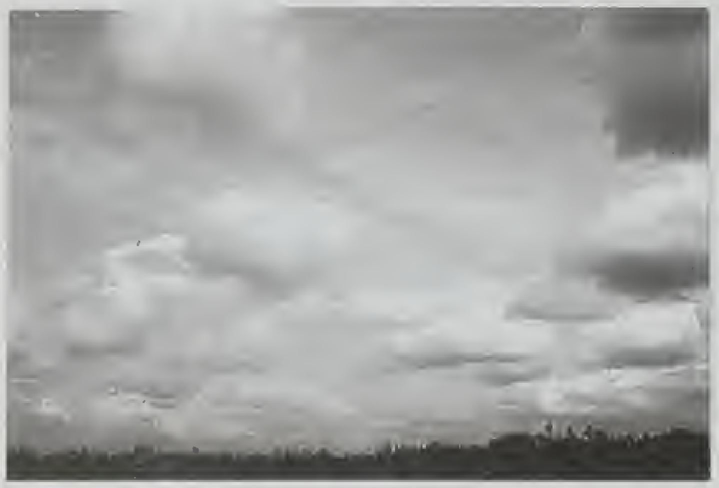


Fig. 10-9. Scattered Cumulus Clouds—Fair Weather.

tails and may be as high as 50,000 feet. **CIRROSTRATUS CLOUDS** are flat. They are the lowest of the high level clouds. Their altitudes vary from 20,000 to 30,000 feet (see fig. 10-10).

Middle level clouds have the prefix alto-. Their average altitude is about 10,000 feet. They may be **ALTOCUMULUS** or **ALTOSTRATUS** depending on whether they are puffy or flat (see fig. 10-11).

The importance of clouds lies in what they can tell you about weather. Clouds tell you that a front is approaching. Cumulonimbus clouds tell you that thunderstorms are forming. Altostratus clouds tell you that a warm front is approaching. Cumulus clouds are fair weather clouds. In general, as a front approaches, clouds become lower and lower.

Weather Clues from Clouds

Clouds tell you where you are with relation to an approaching front. They also tell something about the weather. When you see clouds moving leisurely across the sky, you can expect continued fair weather. You can look for wind and rain when they scud rapidly overhead.

When small clouds decrease or melt away towards sunset, expect fair weather. Increasing and lowering clouds mean unsettled weather ahead.

Cold Front Clouds

About 150 miles ahead of the usual cold front are high sheets of altocumulus clouds. In the summer, the front is probably about 12 hours away. In the winter, the front may be only a few hours away.

As the front nears, **NIMBUS** and, perhaps, cumulonimbus clouds appear (see fig. 10-13). Nimbus clouds are those from which rain is falling. They are the lowest of the clouds. The cumulonimbus clouds are **THUNDERHEADS**. If the front contains thunderstorms, it will have thunderheads.

As the front passes, the clouds rise and become altostratus or altocumulus and possibly cumulus. The storm is over. You can probably expect at least two to three days of cool, or cold, clear, dry weather.

Warm Front Clouds

High, thin cirrus clouds extend as much as

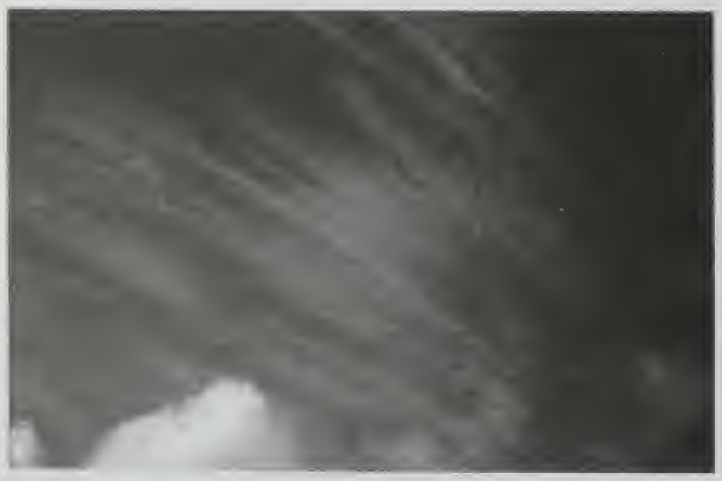


Fig. 10-10. Cirrus Clouds

Fig. 10-11. Altostratus Clouds—Overcast Sky, Frequently with Rain

1,000 miles ahead of a warm front. These are clouds formed from warm, moist air that has risen up and over the retreating cold air mass. As the front slowly advances, the clouds thicken and lower. High level cirrostratus clouds become mid-level altostratus clouds and rain or snow begins to fall.

After the warm front passes, rain or snow may continue to fall while the clouds gradually rise. The wind direction shifts clockwise, for example, from southwest to northwest. Rain, mist, or fog may linger. Some clearing begins.

FOG

Fog is a cloud in contact with the earth's surface. It consists of water droplets or ice crystals which form when air is cooled below its dew point. Fog is the most frequent cause of limited visibility. It is also the most common weather hazard. The speed with which fog can form makes it especially hazardous. It is not unusual for visibility to drop to less than one mile in a few minutes.

Conditions Favoring Fog Formation

Moisture ladened air is essential for fog formation. That means the conditions are usually ripe in coastal areas. However, fog can and does occur anywhere. Fog usually forms around microscopic particles such as dust, soot, and chemicals. Thus, it occurs frequently in industrial areas. Fog occurs most frequently in colder months but the season and frequency of occurrence vary from one area to another.

Advection Fog

Of the several types of fog, the one which is of greatest concern to boaters is called **ADVECTION FOG.** It occurs in coastal waters and is caused by warm, moist air from the land blowing over cold water. It is a concern for boating since it moves rapidly in dense "banks" that can overtake and surprise unwary boaters. Advection fog can reduce visibility to a few feet in a matter of minutes. It occurs most frequently in cold seasons.

Predicting Fog

Fog can be forecast with a high degree of accuracy. Factors that aid predictions are historical, wind strength, air temperature, air moisture, the air temperature-dew point difference, and others such as sky appearance.

Historical predictions are based on questions such as "Did fog form last night?" "Are the conditions the same tonight?" If the answers are, "Yes" then it is likely that fog will form again tonight.

Wind strength is important in fog formation. Warm, damp, gentle, and steady wind without gusts favors the formation of fog. This is especially true if the warm, damp, wind is blowing over water that is cooler than the air.

If the air temperature and the dew point in early evening are within 10 degrees of each other, you can expect fog. The air has almost all the moisture it can hold. Any lowering of its temperature will cause the formation of water droplets.

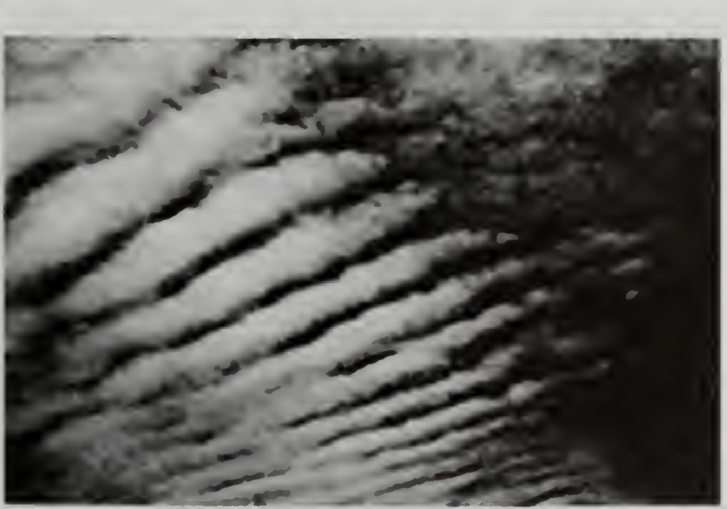


Fig. 10-12. Altocumulus Clouds

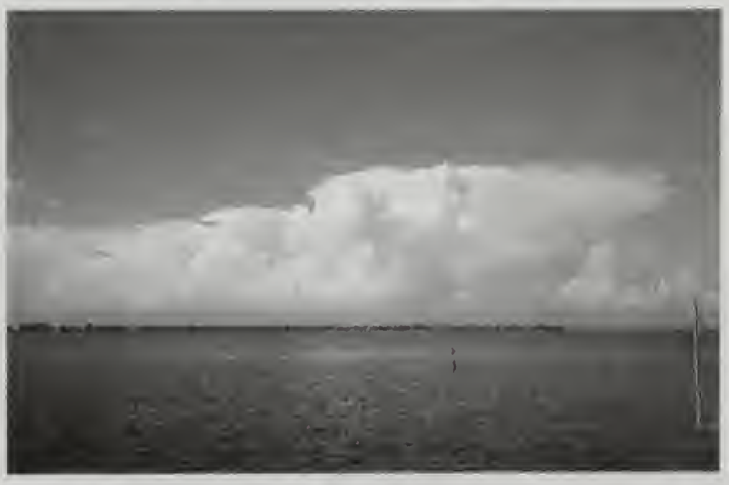


Fig. 10-13. Cumulonimbus Clouds (Note Anvil-Shaped Top)

A variety of other factors aid in predicting fog. A hazy sky that is not very blue is a forerunner of fog. When the sky is like this, the horizon is poorly defined. At night, halos around lights mean high air moisture content. Finally, is the time of the year right for fog?

Fog Precautions

As with other bad weather, it is advisable not to boat in a fog. If it's foggy, don't go!

If you are on the water and fog settles in, take note of your position. Record it and the time. If you do not know where you are before the fog settled in, you will not know later on.

The next important thing is to reduce your speed. Assign lookouts at the bow and stern to watch and to *listen.* Listening in a fog is even more important than watching. The direction of sound is difficult to determine. The water droplets distort it. If you need to hear better, stop your engine and listen. If you are out of shipping lanes and other frequently traveled waterways, consider stopping and anchoring. You can hear better under these conditions.

Above all else, remember the sound signals you must give when underway or anchored in fog. If you have forgotten them, look in chapter 6 to refresh your memory.

NON-FRONTAL WEATHER

Stormy weather also occurs where there are no large air masses and fronts. Non-frontal weather includes thunderstorms, tornadoes and waterspouts, and tropical storms.

Thunderstorms

As already discussed, thunderstorms may accompany cold fronts. Thunderstorms can also occur in non-frontal weather. Summer thunderstorms are usually this type. Regardless of its cause, a thunderstorm is probably the storm most feared by boaters. A thunderstorm may arise in a short time and produce very strong winds. Cumulus clouds in the morning may mean thunderstorms later in the day. Boaters should listen to National Weather Service radio broadcasts.

Although the winds and heavy rains of thunderstorms are dangerous, they are not nearly as dangerous as the storm's lightning. The National Weather Service calls a thunderstorm "severe" if its winds are 50 knots or greater. It is also severe if it has hail that is 3/4 of an inch or larger. And if it has a tornado in it, it is severe.

Thunderstorms form in rising, moist air. The advancing edge of a cold front or surface heat can provide the lift. There are usually three stages in the formation of *local* (non-frontal) thunderstorms.

Stage One

In the first stage, land heats and the air above it rises. If the air is moist, some of its moisture condenses and light, fluffy cumulus clouds form. Cloud development may not stop with cumulus cloud formation. If there is enough heat, the air will continue to rise and the cumulus clouds will develop vertically. They may rise in a column 15,000 to 25,000 feet high at this stage. In rising to these heights the air temperature may cool as much as 80 degrees Fahrenheit to well below freezing at the top of the cloud. Even so, the air is still warmer than the surrounding air. As the air cools, its moisture condenses. This releases large amounts of heat. This heat energy is the power behind the developing storm.

Stage Two

In the second stage, the storm matures. At this point, clouds often reach a height of 40,000 feet. Heights of up to 80,000 feet have been recorded. The higher the cloud, the greater the release of energy and the more severe the storm.

As the air rises, its water vapor condenses and precipitation occurs at the outer edges of the column. The falling rain or hail further cools the air in the column, creating downdrafts and heavier rains. Air is still rising in the center of the column, bringing in more moisture. This air may reach a speed of as much as 6,000 feet per minute.

The rising air may catch descending hailstones, if there are any, and carry them back up the column. During the trip up the column, more moisture forms on the hailstones and freezes. Thus, the hailstones grow in size. If the updrafts are strong enough, a hailstone may make several trips up and down the column, growing in size with each trip.

The cold, descending air accelerates and

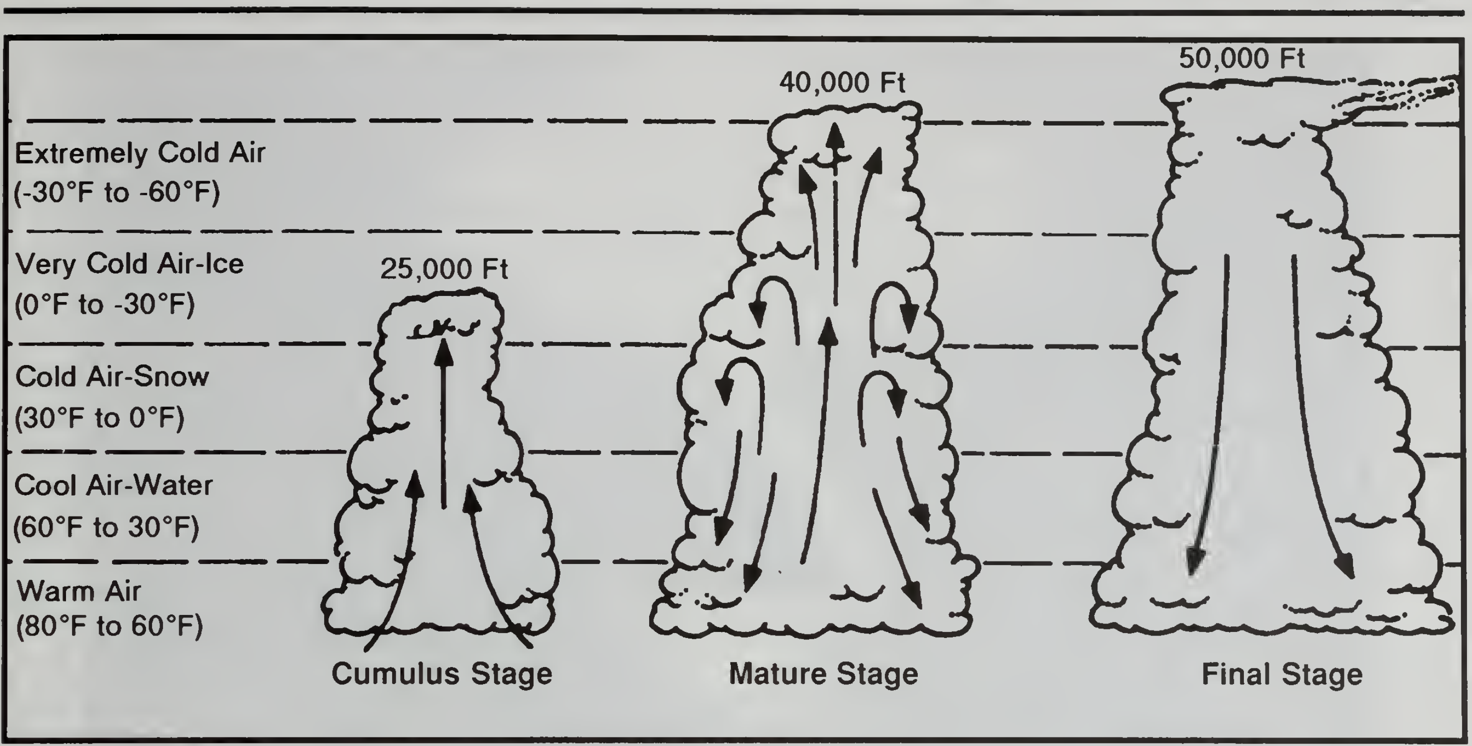


Fig. 10-14. Thunderstorm Development

may reach speeds of as much as 2,500 feet per minute. When it reaches the surface it spreads outward. This produces strong, gusty winds, a sharp temperature drop, and a rapid rise in pressure. The surface wind is a "plow wind" and its leading edge is the "first gust."

Windshear occurs frequently in squall lines that appear before thunderstorms. A squall line is a roll of black, towering clouds that may reach heights of 40,000 or more feet. Squall lines often develop ahead of cold fronts in moist, unstable air. They may also develop in unstable air far away from any front. As the squall line passes, there is an abrupt change in wind direction. This is a wind shear. Squall lines present a serious weather hazard for boaters.

Stage Three

In stage three the storm begins to move. You may be able to tell the direction of its movement from the anvil shaped top of the cloud. The anvil points in the direction toward which the cloud is moving.

At this point, the falling air cools the earth's surface and the storm loses part of its energy source—hot air. The entire cloud becomes sinking air. With no ascending air to cool, rain stops. The storm dies.

When Thunderheads Form—

On most summer days, afternoon cumulus clouds are capable of turning into thunderheads and thunderstorms if there is enough moisture in the air. Keep an eye on them. You may be able to run for safety before there's any danger.

In hazy weather, you may not see the thunderheads forming. Haze limits visibility and is ideal weather for thunderstorms.

On such hot, muggy, hazy afternoons, you should be alert for static on your AM radio, the sound of distant thunder, or the flicker of lightning. Stay close to port so you can run in if necessary. If you are sailing and do not have auxiliary power, be especially alert. The winds may die shortly before the storm begins. This is no time to be becalmed. If there is a threat of bad weather, have all hands don their life jackets, batten your hatches, and tie down all loose equipment.

How Far Away Is the Storm?

Lightning heats air. This makes it expand rapidly and creates a partial vacuum. It then cools rapidly and rushes back in to fill the vacuum. The sound of the air rushing into the vacuum is thunder. For practical purposes, you can consider that lightning and thunder occur at the same time.

Fig. 10-15. Lightning Over Water
(Courtesy Miss Ryan Cotney,
Englewood Elementary School 4-H Club, Tuscaloosa, Alabama.)

You will see the lightning before you hear the thunder. Sound travels much more slowly than light, about 1100 feet per second. It takes sound about five seconds to travel one statute mile or 1.7 kilometers. Light travels 186,000 miles per second.

When you see a flash of lightning, count slowly one thousand and one, one thousand and two, one thousand and three,.... Each five counts tells you the lightning is about one mile away. Be careful that you relate the sound to its appropriate flash. This may be difficult if the lightning is nearly continuous.

Microbursts

In 1976 the U.S. Government identified **MICROBURSTS** as possible hazards to landing aircraft and to pleasure boats. The downdrafts from thunderstorms act in the same manner as the downdrafts in front of squall lines. Cold downdrafts meet warm air and cause wind directions to change suddenly. These downdrafts radiate out from the thunderheads where they hit the surface in what is called a microburst. A microburst is strongest in the direction in which the thundercloud is moving. Its winds may exceed 100 knots.

Microbursts may occur even when there is no rain below a thunderhead. Falling rain in a thunderhead may evaporate before it reaches the earth's surface. This phenomenon is a dry microburst. Because there is no visible sign of windshear, it is difficult to predict. Microbursts can occur several miles away from an associated squall line. Even if it is not raining, be alert for possible strong gusts. Near a thunderstorm, these may be from a direction different from the prevailing wind.

Lightning

Lightning is a serious boating hazard. It takes place between clouds, within clouds, and between clouds and the ground. Never take shelter under a tree when you are on land because lightning usually strikes the tallest object around. When you are out on the water, you may be the tallest thing for miles around.

A few pointers on lightning:

- The more frequent the lightning, the more severe the storm.

- Lightning strokes increase in number as the storm grows.
- Decreasing lightning means the storm is dying.
- At night, frequent distant flashes along a large sector of the horizon suggest a probable squall line.

The best way to escape the dangers of lightning is to avoid it. This is a strong argument in favor of understanding weather. The more "weather-wise" you become, the less likely you are to be caught out on the water in a thunderstorm.

If You Are Caught

If you are boating and find yourself in a thunderstorm, have each person aboard don a life jacket. Next, pinpoint your exact location before the storm arrives. Heavy rain will reduce your visibility.

Reduce your boat's speed and keep a sharp lookout for other boats and obstructions. Secure all hatches and ports. Strap down or stow in lockers all loose gear on or below decks.

Once the storm hits, try to take the first (and heaviest) gusts of wind on your bow, not abeam. Heading into the wind is the most seaworthy position for most small boats. Approach waves at a 45° angle. This will keep your propeller under water. It also reduces pounding and provides a safer and more comfortable ride.

Stay low in the boat. Don't make yourself the tallest target. Keep away from all metal objects. Lightning does not have to strike a boat directly for strong electrical charges to be aboard. If it strikes the water near your boat, it may affect the metal parts on the boat.

You can lessen the danger of a lightning strike by staying off the water during thunderstorms. You can also lessen it by having a grounding system installed. The system is similar to those found on buildings and other land structures. A grounding system may prevent a lightning strike. If not, it may provide lightning a path to reach ground (water) without causing damage or injury to you or your boat. The installation of a grounding system is a job for a professional. Don't try it yourself and don't assume that the builder of your boat provided any lightning protection for it. Builders seldom provide such protection, least of all in small recreational boats.

Ground Your Boat?

There is some disagreement about whether you should have your boat grounded. Most thoughtful opinion favors a grounding system.

One school of thought believes that grounding a boat gives lightning an unobstructed path through the boat to the ground. These people also believe that a grounding system prevents lightning from jumping to other metal objects or people aboard the boat.

Some people believe that grounding a boat makes it more attractive to lightning. They believe, too, that the force of a lightning bolt exiting a boat can damage its hull. This may sink the boat.

Most physicists believe that a good grounding system serves to lead lightning into the water by the most direct means. They also believe that a good grounding system can prevent lightning strikes.

According to physicists, a good ground system neutralizes the difference in electrical potential between the water and the air and prevents static buildup. This is the reason farmers put lightning rods on buildings such as barns. There are, though, no guaranteed safeguards against lightning. It is very unpredictable and powerful.

Tornadoes and Waterspouts

Tornadoes are usually spawned in the squall lines ahead of cold fronts. However, they occur frequently in hurricanes. They also occur in calm, sunny weather.

Tornadoes usually occur over land and then sometimes move out over water (fig. 10-16). A tornado over water is different from a similar-appearing phenomenon called a waterspout.

Tornadoes always have a counterclockwise circulation. They almost always move from southwest to northeast although they sometimes move in the opposite direction.

A tornado is a whirlpool of air with a relatively small diameter that extends downward from a cumulonimbus cloud. It has a funnel-like appearance. The average diameter of the funnel is about 750 feet and the wind speed at its center may exceed 250 knots.

If a tornado appears to be standing still or growing larger, watch out! It is moving toward you. Move at right angles to its path as fast as you can and you may avoid it.

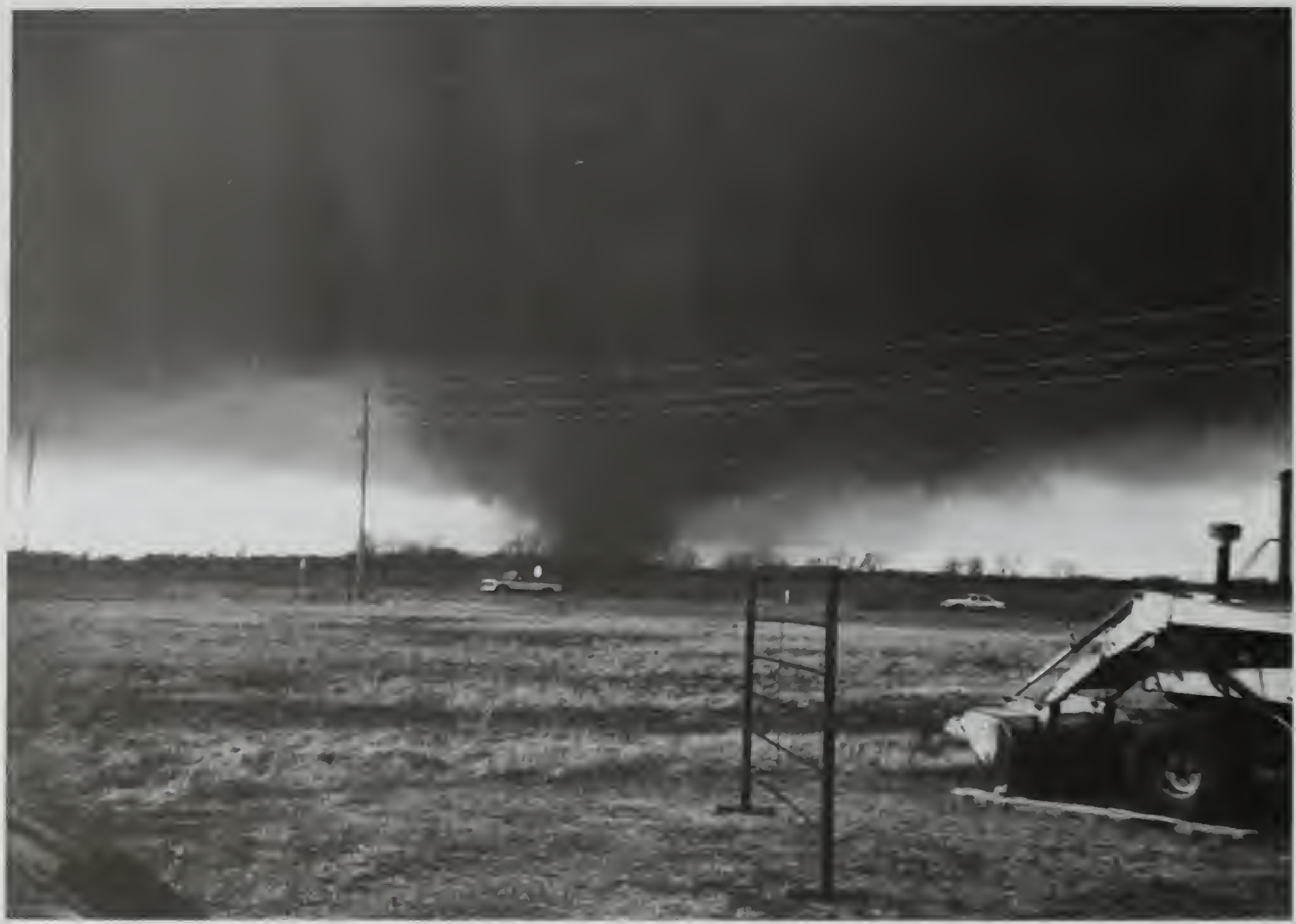


Fig. 10-16. A Tornado.
(Photo courtesy of Julie Cargill, Burrton, Kansas)

Waterspouts

Waterspouts come from two different sources. The first is a tornado that has gone to sea. This is not a true waterspout. Since it is over water, though, it may contain large quantities of water. Both the water and the tornado's wind make it dangerous for boaters.

Unlike tornadoes, waterspouts do not develop in weather fronts. They usually occur in fair weather and always over water. Their winds may circle either clockwise or counterclockwise. They are more like dust devils over land than like tornadoes. Waterspouts may have diameters of 20 to 200 feet.

Tornadoes form in clouds and grow downward toward the earth. They may or may not reach the earth. Waterspouts, though, form close to the water's surface and grow upward. They are usually small, of short duration, and less dangerous than tornadic waterspouts.

Although waterspouts are less violent than tornadoes, they are a danger to boats. They are more common in the Tropics than in the middle latitudes. They may last from ten minutes to half an hour. As they subside, they dump large quantities of water. This can swamp a small boat.

Tropical Storms

Tropical storms are non-frontal storms that form in the Tropics. They have counterclockwise circulation in the northern hemisphere.

Tropical Waves

Tropical storms usually begin as **TROPICAL WAVES** of low pressure and move from east to west. Good weather precedes tropical waves. Extensive cloudiness follows them. Often, rain and thunderstorms accompany the cloudiness. Tropical waves occur in all seasons. They are more frequent and stronger in summer and early fall.

Tropical Cyclones

A **TROPICAL CYCLONE** is a general term for any low pressure area that forms over warm, tropical waters. All require warm, moist air to power them. Over cold water, they lose strength. The strength of tropical cyclones comes from the heat of the water over which they form.

Tropical waves can develop into tropical cyclones. Tropical cyclones are named according to their intensities based on average one-minute wind speeds. Wind gusts may be as much as 50 percent higher than the average wind speed.

There are three levels of tropical cyclones; **TROPICAL DEPRESSIONS, TROPICAL STORMS,** and **HURRICANES** or **TYPHOONS**. An intense tropical cyclone in the Atlantic and eastern Pacific is a hurricane. In the western Pacific Ocean, it is a typhoon. Near Australia, it is a "willy-nilly." In the Indian Ocean, it is a cyclone. No matter what their names, they are serious storms. They absorb tremendous amounts of energy from the water over which they form. Hurricanes require water temperatures of at least 79°F for their formation.

Winds in Tropical Cyclones

The highest sustained winds in tropical cyclones are:

- Tropical depressions, 34 knots,
- Tropical storms, 35 through 63 knots, and
- Hurricanes or typhoons 64 knots or more.

Hurricanes

On land, the greatest property destruction and loss of life in a hurricane usually results from the storm surge. Hurricane force winds blowing steadily, pile up the sea before them. The piling up may extend for hundreds of miles. In effect, the entire sea rises up. Storm waves are on top of this surge. The heights of storm surges vary from about 4 feet to over 18 feet.

Your boat will probably need more protection from the storm surge than from the wind. Even so, protection from the wind is not unimportant. Wind-blown objects may damage it. There are many suggested ways to protect your boat in a hurricane. None of them is completely satisfactory. If you live in a hurricane-prone area, get advice from seasoned boaters. Weigh the advice. Then make up your own mind.

Well-developed hurricanes average 300 miles in diameter. At the center or eye of a hurricane is a low pressure area that may be 15 to 25 miles in diameter. Since the winds of a hurricane rotate strongly, the center is a very low pressure area of calm winds. Although the sea below the eye is heavy and confused, the wind in the eye seldom reaches 15 knots.

The Atlantic Ocean hurricane season is June through November although hurricanes also occur in other months. Early and late season hurricanes usually form in the Gulf of Mexico and the Caribbean Sea. They develop rapidly.

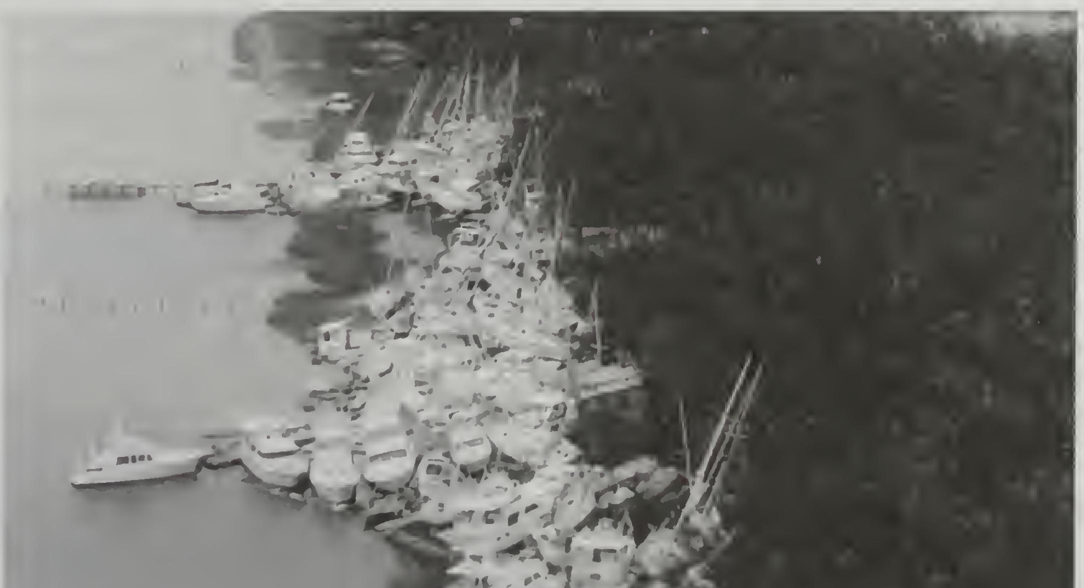


Fig. 10-17. Hurricane Damage from Hurricane Hugo
(Courtesy of Lt. Mark Torres, USCG, Air Station Elizabeth City)

The mid-season storms of August and September may begin as tropical waves coming off the coast of Africa. They develop slowly.

Hurricanes also begin off the west coast of Mexico. These usually do not present threats to the continental U.S. They often reach the Hawaiian Islands and beyond.

The National Weather Service is a continuous source of information for tropical storms and hurricanes. Keep abreast of its warnings and heed them.

Don't wait until the last minute, though, to take measures to protect your boat. You may find safe harbors filled and storm equipment no longer available. Besides, you may find your time occupied in taking care of your family and home.

Above all, do not stay on your boat during a hurricane, even a minimal one.

A FURTHER INVITATION

If you would like to know more about weather, consider joining the Coast Guard Auxiliary. We have an excellent course, open only to members.

11

Your Boat's Radio

A person's best friend may be a dog, but a boater's best friend is a radio. Boats carrying six or more passengers for hire, as well as many other commercial vessels, must have radio equipment. Most privately operated boats are not required to have radios. Even if you are not required to have one on your boat, you should have one.

RADIOS USED ON BOATS

Boaters use several types of radios. These include **VHF-FM, SINGLE-SIDEBAND (SSB), CITIZENS BAND (CB)**, and **CELLULAR TELEPHONES.**

VHF-FM Radios

The most commonly used marine radios are VHF-FM. They are also the most useful. Two types are available, full-sized installed and hand-held portable. You can use VHF-FMs to call for help, arrange for a berth, get weather information, call home, or talk with other boaters. A hand-held set is a good standby if your full-sized set fails.

Fig. 11-1. A VHF-FM Radiotelephone Set
(Photo Courtesy of Uniden Corporation of America)

The average maximum ship-to-ship range of a VHF-FM radio is about 10 to 15 miles. The ship-to-shore range may be 20 to 30 miles depending on the height of the onshore antenna. A hand-held VHF-FM radio has considerably less range.

Single-Sideband Radios

A single-sideband radio (SSB) varies in range depending upon the time of day, the season, and the frequency of the channel being used. The range can be from as little as 25 miles to throughout the world. Specific information on the selection of channels can be found in the operator's manual which comes with the radio. You should study the manual carefully before using the radio.

SSB radios cover the marine portion of the medium frequency (MF) band (2.0 to 3.0 MHz) and the international marine channels in the high frequency (HF) band (3.0 to 23.0 MHz). SSB radios include distress, safety and calling channels, ship-to-ship channels, and **PUBLIC CORRESPONDENCE CHANNELS** that can connect you to the public telephone system. You will learn more about these channels later in this chapter.

There are four Coast Guard stations within the continental United States and one in Hawaii that provide service to SSB radios. Their emergency frequency is 8364 kilohertz (kHz).

Since few recreational boaters have SSB radios, this text does not discuss them at length. You probably do not need one unless you are planning an offshore trip or a trip to a foreign port.

CB Radios

Citizen's Band (CB) radios are inexpensive and popular. In many inland areas CBs are common on boats, and often are the only radios boats have. They serve useful functions on lakes and rivers where the Coast Guard does not have a presence. The only radios many river marinas have are CBs. A CB can serve as a back-up for your VHF-FM. If it fails, you may get help through your CB.

CBs have several limitations. One of these is their short range. Too, there are so many sets in use that the channels are overcrowded. Also, many CB owners fail to exercise discipline and radio etiquette and overpower their stations. In addition, there is no common distress channel. Furthermore, CBs are AM radios, and therefore, susceptible to static caused by lightning. In a storm when you need them, they are least reliable. Channel 9 is the channel most often used for emergency calling but the Coast Guard does not monitor it. For these reasons, the Coast Guard does not encourage the use of CBs as the first or only means of radio communication for boaters.

Amateur Radio Service

If you are a short wave amateur operator, called a "ham," you might use a short wave radio aboard your boat. Many of these people have found their sets useful in marine and other emergencies such as severe storms and other disasters. These radios operate in eight frequency bands and reach around the globe. There are 420,000 licensed ham operators in the United States. More than 100,000 of them may be on the air at any one time and willing to assist you.

Before you can use the amateur radio service, you must pass a Federal Communication Commission (FCC) examination and have a license and an assigned call sign. There are 18 amateur, maritime networks throughout the world which cover international waters as well as coastal waterways. These nets operate 24 hours a day with operators trained to handle emergency traffic and to provide the licensed amateur with an excellent communications network. Many amateur radio operators are listed in telephone directories.

Cellular Telephones

In recent years, the use of cellular telephones has gained in popularity, and receiving stations are widespread. Although cellular telephones are not marine radios, they may serve in an emergency. You may be able to use your cellular telephone to call for help on rivers and lakes where the Coast Guard does not have a presence. Some Coast Guard stations will answer when *CG is pressed.

There are two drawbacks to the use of cellular telephones in an emergency. First, you may be too far from a receiving station for your signal to be received. Second, although the locations of SSB and VHF-FM radios can be pinpointed by means of radio direction finders, there is no such technology for locating cellular telephones. If you don't know where you are, your telephone signal will not help to locate you.

FUNCTIONS OF RADIOS

Marine radios serve three important communications functions. Their purpose is to send and receive messages about *safety*, *operations*, and *commerce*. No other type of message is permissible.

Safety Messages

There are three types of safety messages, **DISTRESS, URGENCY**, and **SAFETY**. Use distress messages when there is grave or imminent danger to life or property and you need immediate help. Use urgency messages when there is a chance that a non-life-threatening situation may become one. Safety messages relay important information about weather or safety of navigation.

Operations Messages

Operations messages deal with exchange of information about navigation or the movement or management of vessels. For example, you

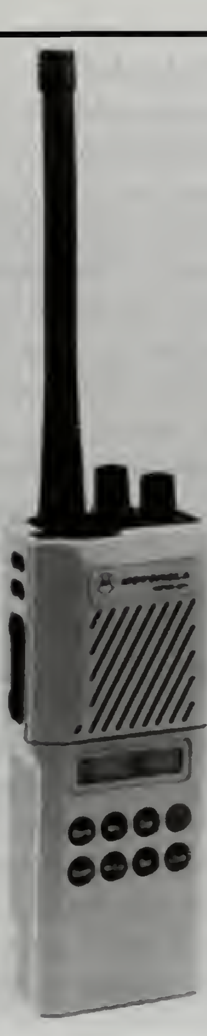


Fig. 11-2. A Hand-held VHF-FM Radio
(Photo Courtesy of Shakespeare, Electronics and Fiberglass Division)

can call a lock master for instructions, or you may call a bridge tender to open a drawbridge. Too, you may call to secure a berth or boat repairs. And you can exchange information about fishing or scheduling a rendezvous with other vessels.

Don't chitchat on your marine radio. It's against the rules. It clutters up important channels and interferes with the basic radio functions.

Commercial Messages

Commercial messages are what their name implies. These messages must be about the business of the vessel. They concern economic and commercial matters directly related to the use of the boat. Recreational boaters should not use the radio channels set aside for this function.

LICENSES

You must have a license for any equipment that sends radio signals such as a VHF-FM or SSB radio, an Emergency Position Indicating Radio Beacon (EPIRB), or a radar. Under some circumstances, you may need an operator's permit.

Station License

You must have a **SHIP STATION LICENSE** for VHF-FM and SSB radios. Furthermore, if you have an SSB radio, you must also have a VHF-FM. To get a license for an SSB, you must show the Federal Communications Commission (FCC) a need for the radio. The FCC issues ship station licenses.

To get a Ship Station License, apply to the FCC using FCC form 506. You can get the form from a marine radio dealer or, possibly, from your instructor. Be certain that the form you use is current. You can get current forms from the *Federal Communications Commission, Forms Distribution Center, 2803 52nd Avenue, Hyattsville, MD 20781* if you can't get them elsewhere.

When you buy a VHF-FM radio, the form may be packaged with it. Submit your application with the required application fee to the *Federal Communications Commission, Marine Ship Service, P. O. Box 358275, Pittsburgh, PA 15251-5275.* The license is good for 10 years.

If you operate off-shore, you can apply for SSB, EPIRB, and radar licenses on the same application that you use to apply for your VHF-FM license. You can do this even though you will not add this equipment until a later date. If you apply for these licenses separately, you will have to pay additional fees.

You can use a part of FCC form 506 for temporary authority to operate your ship's radio station *after* you have mailed in your application. Until you get your station license, you will use your boat's registration number for your call sign. You must post the temporary permit near your ship's radio.

The Coast Guard inspects VHF-FM and SSB station licenses during routine boardings. If you don't have a license for your station, the charge can be a criminal misdemeanor. The penalty is a fine of up to $10,000 or one year in prison or both.

FCC rules require that you post your station license at the principal control point of your radio. You may, instead, post a legible copy. The posted copy must tell the location of the original. If you can't post your license, keep it where it is readily available for inspection. This means you must keep it on your boat.

The station license does not cover equipment such as commercial radio sets, radio direction finders, SATNAV receivers, GPS receivers or Loran sets. You do not have to have licenses for them since they do not send out radio signals.

If your station set is hand-held, you must have a license for it. If your hand-held set is in addition to your station set and broadcasts on the same frequencies, your station license covers it. It is against FCC rules to transmit with a hand-held VHF-FM radio from shore.

If you should change your mailing address, your legal name, or the name of your boat, you must let the FCC know in writing. You also must tell the FCC in writing and return your license if you sell your boat. If you add or replace a set that operates on the same frequency band, you do not have to do anything. If you add a radio or another piece of equipment that transmits on a new frequency, apply to the FCC on form 506 for a change in your license.

Licenses for Other Radio Sets

CB sets do not require licenses. The common carrier you pay for service holds the license for your cellular telephone. An amateur radio operator must have a license issued by the FCC. The FCC issues licenses to applicants after they pass a test based on knowledge of short wave radio equipment and its use.

Operator's Permit

You do not need an *operator's* permit to use your licensed VHF-FM radio set in domestic or international waters. If you plan to dock in a foreign port, you must have a **RESTRICTED RADIOTELEPHONE OPERATOR'S PERMIT (RP).** Also, if you leave a foreign port to enter and dock at a United States port, you must have an RP. Use FCC form 753 to apply for your RP. The fee is $35. The RP is good for your lifetime.

SELECTING YOUR VHF-FM RADIO

All marine radios must be acceptable to the Federal Communications Commission (FCC). This means the radio meets required minimum technical standards. If it does, it will have a label certifying compliance with FCC standards.

VHF-FM radios differ widely in price and basic characteristics. Shop around to see what is available before you buy. When you look at sets, ask about their *sensitivity*, *selectivity*, *audio output*, *signal strength*, *available channels*, *type of tuner and readout*, and *the amount of current they use*.

Sensitivity

Sensitivity is the ability of a radio set to pick up distant signals. It is the number of microvolts needed to produce a 20 dB (decibel) sound level on the radio. A dB is a measure of loudness—the higher the dB, the louder the sound. The 20 dB level is a standard you can use to compare sets.

The less the microvoltage a set needs to reach the 20 dB level, the more sensitive it is. Thus, a set using .5 microvolts is more sensitive than one using 2.5 microvolts. If your set is too sensitive, it may "talk" continuously when close to shore. If possible, observe several sets on friends' boats and select the model that performs best.

Selectivity

Selectivity is a measure of how good a receiver rejects signals from other channels close to the channel you are using. The units for selectivity are also dBs but the measure is negative dBs. The most selective sets are those with the highest *absolute*[1] dB rating. A set with -.75 dB selectivity will do a much better job than one rated at -.55 dB.

Audio Output

Audio output tells you the loudness of the radio. Your radio needs to be loud enough that you can hear it over the sound of your engine.

---

[1] The term "absolute" means the number without its sign. Thus, the absolute value of -.75 is .75 which is greater than the absolute value of -.55 which is .55.

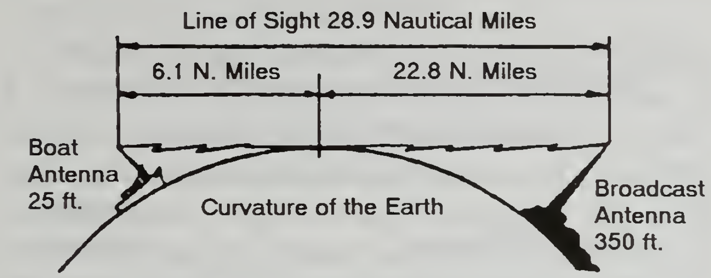


Fig. 11-3. Line of Sight Distances

Small radios usually have small speakers and do not produce loud sounds. Thus, hand-held VHF-FM radios usually do not produce sounds as loud as full-sized ones.

If the radio has an outlet for an external speaker, you can use one to improve the sound level. The range of audio output measures for good sets is from about .25 to 5 watts. The larger the number, the louder the output.

Signal Strength

Your VHF-FM set must be able to transmit on a power of one watt. It also can have a maximum power of 25 watts. Most hand-held sets transmit on a "low" power of one watt and a "high" power of 5 watts. One watt is more than enough strength for short distances. It is mandatory to use the one watt setting when transmitting in a harbor. Make it a point to see the signal strength of your VHF-FM set before you buy it.

Signal Suppression

If there are two VHF-FM sets operating on the same channel in the same area, the stronger one suppresses the weaker. Unlike AM broadcast where you can get two stations at the same time, with FM you get only the stronger station. Limit your signal distance by using the lowest power needed for your communication. Don't reach out of your area and, perhaps, suppress an important communication from another vessel.

Line of Sight Transmission

VHF-FM is a "line of sight" system. It reaches only a little way beyond the horizon. This is sufficient for most marine communications. An important land station, such as a Coast Guard station, has a high antenna. This increases its line of sight. If one antenna can "see" another, communication is possible.

With 25 watts of power, your VHF-FM set will reach as many stations as it could reach with more power. A more powerful radio would only send its signal farther out into space.

Available Channels

The VHF-FM frequency band includes 73 channels of which 55 are in use in the United States. Three of these are weather channels. Your set can have as few as three of these 73 channels.

USA and International Channels

Your VHF-FM radio may have a two-position switch labeled USA and International. This is because the channel frequencies used in the USA differ in some instances from those used in foreign countries. Where there is a difference, the USA channel number includes the letter A.

For example, one of the channels used by the Coast Guard is channel 22. Since the USA channel 22 has a different frequency than a foreign channel 22, the Coast Guard channel is 22A. You say this as "22 alpha." If the Coast Guard tells you to shift to 22 alpha, be certain that your switch is in the USA position.

Channels You Need

Your VHF-FM set must have at least channel 6, channel 9, channel 16, and one other channel. Channel 6 is the Intership Safety channel. Channel 16 is the safety, urgency, and calling channel, and channel 9 is the alternate calling channel for non-commercial vessels. Use channel 9 to reduce the use of channel 16. Use channel 16 for emergencies. In addition, if your boat is longer than 65 feet, your VHF-FM set must have channel 22A. If your boat is longer than 65 feet and you boat on the lower Mississippi River, you must also have channel 67. Channel 67 is used for intership or "bridge to bridge" communications.

You will need more than the required minimum number of channels. Besides channels 6, 9 and 16, you should have at least the weather channels, channel 22A, and a working channel such as 68, 69, 71, 72, or 78. If you have only one working channel, it probably should be channel 68. It is a noncommercial channel that you can use to talk with another vessel or a land station.

An all-channel set has 73 channels. It is not much more expensive than one with a few channels. Remember, though, you can't use all 73 of these channels. The channels listed in table 11-1 are the only ones recreational boaters may use. Even if your radio has more channels available, you are not permitted to use them.

Channel Selector

During a transmission to another vessel or a coastal station, it is necessary to switch from the calling channel to a working channel. You do this on some sets by rotary dials. The numbers on the dials may be small and difficult to read. In poor light, the problem may be worse. Cheaper sets often have rotary dials.

Some sets have digital readouts. These sets are easier to change from one setting to another. You use a number pad to enter a setting. The digital readout is even easier to read in dim light than in good light. A good set includes a dimmer switch for night operation.

Scanning sets are available. They may scan as few as two channels or as many as the total available. They do not scan the weather channels. If you purchase a scanner be certain that it includes channel 9 as well as channel 16. If a message comes in on a preset channel, the set automatically switches to that channel.

Current Usage

The amount of electrical current a set uses is important. The "Amp Draw" is a measure of the current a set uses when sending or receiving. This is important since it shows how much drain is on your battery. For hand-held sets, it gives you some idea of how long you can operate the radio before recharging the battery. The batteries of most hand-held sets need charging after about three hours of use.

Efficient hand-held sets draw as little as .02 amp on standby and .8 amp when sending. Efficient full-size sets require as little as .2 amp on standby. When sending they use more power. The most efficient ones use about 5.0 amps.

TABLE 11-1

VHF-FM Channels Used for Various Non-Commercial Messages

Type of Message	Suitable Channels
Distress, Urgency, and Safety	16
Alternate Calling Channel (Non-Commercial Vessels)	9
Intership Safety	6
Coast Guard Liaison	22A
Non-Commercial[1]	68,69,71,72,78A
Public Correspondence (Marine Operator)	24,25,26,27,28,84,85,86,87,88[2]
Port Operations	1,5[3],12,14,20[4],63.65.66,73,74,77[5]
Navigational	13
Maritime Control	17
Digital Selective Calling	70
Weather[6]	WX-1 (162.550MHz).
	WX-2 (162.400MHz).
	WX-3 (162.475MHz).

1. Working channels for recreational boats only. Other channels are reserved for working vessels.
2. Only for use in the Great Lakes, the St. Lawrence Seaway, and Puget Sound and its aproaches.
3. Available only in the Houston and New Orleans areas.
4. Channel 20 used only for ship-to-coast messages.
5. Channel 77 is limited to intership communications to and from pilot boats.
6. Weather channels are "receive only."

INSTALLATION

You can install your VHF-FM radio set. You cannot repair or adjust it since this might change its transmitting characteristics. Only an FCC licensed General Class commercial operator can make repairs or adjustments.

Installing Your Radio

Improper power and antenna connections can impair performance. They can also cause equipment damage. When you install your radio, keep it and its speaker as far away from your compass as practicable. Be sure that your power connections are secure and correct. The positive lead from your battery should go to the positive terminal of your set. On a 12 volt system, the positive lead is usually red and the negative lead is usually black. The negative lead goes to the negative terminal. There should also be a fuse somewhere in the positive lead. Installation is not a difficult task.

Your Radio Antenna

Select a good quality antenna in the right frequency band for your radio. A CB antenna should be used only for a CB transmitter. Likewise, SSB antennas are designed only for SSB transmitters. If you use the wrong antenna, you will greatly reduce your ability to transmit and to receive. You may also damage your transmitter if you attempt to transmit without an antenna.

Place the antenna as high in your boat as you can. Sailboaters often place their antennas at the mastheads. This increases their range. Most powerboats use eight foot antennas. When you install one, allow enough room to lay it down for trailering and passing under low bridges.

The **FERRULE** is the fitting at the bottom of your antenna. It is nylon or metal. Nylon is good and will serve you well on lakes and in calm to moderate seas. If you plan to fish or cruise in rougher weather, a metal ferrule is advisable.

Mounts of nylon or metal, usually stainless steel, connect antennas to boats. Whichever one you choose, match it to the ferrule. That is, if the ferrule is nylon, use a nylon mount. Use a metal mount with a metal ferrule.

Antennas differ in **GAIN**. The higher the gain, the farther you can communicate. (Remember, though, VHF-FM is line-of-sight.) It is tempting to select a high gain antenna, but don't do it. With a high gain antenna, you may not be able to communicate.

Figure 11-4 illustrates the radiation patterns of 3 dB, 6 dB, and 9 dB gain antennas. On land, or in a very stable boat you might select a 9 dB antenna. In a pitching and rolling vessel, though, the flat, compressed signal of a 9 dB antenna sometimes will point at the sea and sometimes will point up in the air. It wastes much of its signal. Most small boats should not use antennas with gain ratings above 6 dB.

When you install your antenna, keep it away from masts, shrouds, stays, or other metal that might shield it. If your antenna cable is 25 feet or less in length, you can use the cable that came with the antenna. If you need a longer cable, use a low loss cable. Keep the cable as short as possible.

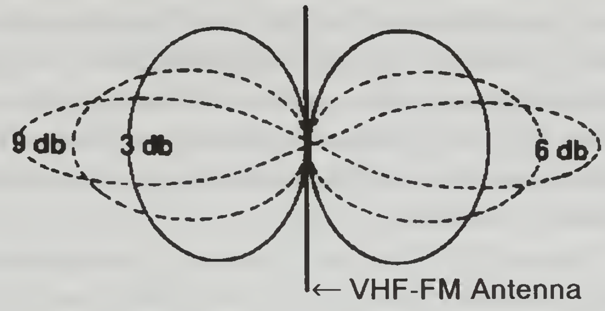


Fig. 11-4. Typical Radiation Patterns of VHF-FM Radio Antennas

OPERATING YOUR VHF-FM

Before you turn your set on, check to see that the high power-low power switch is in the one watt position. This is where you will operate most of the time. Check also to see that the USA-International switch is in the USA position.

Your VHF-FM set is a **TRANSCEIVER.** This means that it is both a transmitter and a receiver. It can only do one of these at a time. When you turn the set on, it is ready to receive. To send, you must press a button or a switch. You will usually find the button on the microphone. It is a "push-to-talk" button.

Usually, the volume control is also the on-off switch. When you turn it, it first turns the set on. As you continue to turn it, the receiving volume increases. The volume control affects *only* the loudness of what you *hear*. The high power-low power switch controls the strength of your transmission.

There is another important switch, the **SQUELCH CONTROL**. It stops the constant noise you hear when you are not receiving a signal from another radio. Turn the squelch control until the noise just disappears. Do not turn it any farther. If you do, you lower the ability of your set to receive signals. Set it just low enough to make the noise disappear and to cut out signals that are so far away that you can't understand them.

MAINTAIN A RADIO WATCH

You do not have to have your set turned on. However, when it is on and not being used for messages and if it is not a scanner, you should stay tuned to channel 9. This is the alternate calling channel for non-commercial vessels. This channel is not monitored by the Coast Guard.

Use it to call other recreational vessels or shore stations. Use channel 16 for distress, urgency and safety messages and to call the Coast Guard if you need to. Channel 16 is the calling channel for commercial vessels. It is monitored by the Coast Guard.

You will do far more listening than talking. Your radiotelephone is a very busy party line with many users. It also is vital for emergency communications. Always listen carefully before transmitting to see if someone else is using the channel or if there is an emergency condition in effect. When you listen, set the squelch so you can understand distant signals.

CHANNELS HAVE SPECIAL PURPOSES

Each VHF-FM channel has an assigned frequency. For example, channel 16 has a frequency of 156.800 MHz for receiving and sending. We will not discuss VHF-FM frequencies, though, since you do not need them. You use channel numbers to tune your set. These are keyed to frequencies by the set. SSB sets use frequency settings, not channels. The SSB distress and calling frequency is 2182 kHz.

Table 11-1 summarizes the VHF-FM channels and their uses. You begin most calls on channel 9. You begin distress, urgency, and safety messages on channel 16.

You shift to channel 6, the *Intership Safety* channel, for ship-to-ship safety messages. If you have an emergency and the Coast Guard or its Auxiliary comes to your aid, it may communicate with you on channel 6.

If you call the Coast Guard, it may request that you switch to one of its working channels. This will probably be channel 22A (USA setting). This is the *Coast Guard Liaison* channel. Initiate your call on channel 16.

Your message on a *noncommercial* channel must be about the needs of your vessel. Typical uses include fishing reports, rendezvous, repair scheduling, and berthing. Channel 72 is only for ship-to-ship messages.

Public Correspondence channels connect your ship's radio with a telephone operator ashore. Through these channels, you can call any telephone. If you plan to use ship-to-shore telephone service, find out what channels it uses in your area, and arrange your method of payment in advance. Since marine telephone conversations can be heard by anyone with a VHF-FM marine radio, you would not want to broadcast your telephone credit card number. Consult your telephone directory for information on how to call a marine operator. Call the marine operator on a Public Correspondence channel.

There are no restrictions on the content of Public Correspondence calls. Remember, though, that your call is over public airways.

In some ports, Vessel Traffic Service systems (see chapter 6) use channels 11, 12, and 14. The *Port Operations* channels are for directing the movement of ships in or near ports, locks, or waterways. Messages must be about the handling, movement, and safety of ships.

Channel 13 is the working channel at most locks and drawbridges. The *Navigational* channels are *Bridge-to-Bridge* channels. These "bridges" are ship's bridges, the places from which they are controlled. Navigational channels are available to all ships, but the messages must be about vessel navigation, for example, passing or meeting other vessels. Keep your message short. The communication between two ships shall not exceed three minutes after the ships have made contact. Your power output must not be more than one watt.

You can talk to ships and coast stations operated by state or local governments on the *Maritime Control* channel, channel 17. Your message must be about regulation and control, boating activities, or assistance to ships.

Channel 70, the *Digital Selective Calling* channel, is an alternative channel for distress, safety, and general purpose calling. *Do not use this channel for voice transmissions.*

SOME NO NOs

Do not send false distress or emergency messages. Hoaxes can lead to loss of life. The Coast Guard answers every distress call regardless of the weather or other conditions. These calls often are sent by children who do not realize the seriousness of their hoaxes.

The Coast Guard works closely with the FCC in identifying offenders. Both the Coast Guard and the FCC have direction finding equipment available. When you are in waters where the Coast Guard has a presence, it is very likely that the location of your broadcast can be pinpointed. The misuse of channel 16 is serious enough that it is a class D felony. Offenders are liable for a $5,000 fine plus all costs the Coast Guard incurs as a result of the hoax. Guard your set against unauthorized use. You are responsible for it.

Obscenity, Indecency, and Profanity

When you use your radio, you are using an extensive party line. Assume that other people are listening. You therefore have a compelling moral obligation to watch your language. You also have a strict legal responsibility. It is a criminal offense to use obscene, indecent, or profane language. The fine is up to $10,000 or imprisonment up to two years or both.

Secrecy of Communication

The Federal Communications Act protects the secrecy of radio communications. You must not communicate the contents of any radio message to anyone other than the addressee or the addressee's agent or attorney unless you are authorized to do so. If you intercept a message, you must not use its contents for your own benefit or the benefit of other people.

This secrecy requirement does not apply to distress messages. Nor does it apply to radio broadcasts meant for general use. It applies to all other communications.

Using Your VHF-FM Radio on Land

Do not use your radio to transmit when your boat is on land, for example, while it is on a trailer. Also, do not make general calls except in an emergency or when your radio is being tested. Instead, direct your calls to a particular station.

COPIES OF THE RULES

Recreational boaters do not need to keep copies of the FCC rules aboard their vessels. However, you can get a copy by writing to: Superintendent of Documents, Government Printing Office, Washington, DC 20402.

Rules Violations

If the FCC believes that you have violated the rules, it may send you a written notice of the violation. If the violation notice covers a technical radio standard, you must stop using your radio until you have the problem fixed. You may be required to have your radio tested and the results sent to the FCC. The commercial operator who conducted the test must sign the results.

If the FCC finds that you have willfully or repeatedly violated the Communications Act or the rules, it may revoke your license. You can be fined and sent to prison.

CALLING ANOTHER STATION

To call another station, first turn your radio on, and make sure it is on low power. Tune it to channel 9, and listen to see if someone else is using it. Next, press the microphone button and speak directly into the microphone. Hold the microphone two to four inches from your mouth, use a normal tone of voice, and speak clearly. Switch to high power (25 watts) if you suspect that the other station is too far away to hear you.

Call the other station by saying, "(Name of vessel or station you are calling, three times) THIS IS (your vessel's name and call sign)." Do not add unnecessary words such as "Come in, Bob" or "Do you read me?" These only add to the traffic on the channel.

After you have called the other station, release the microphone button. If you continue to press the button, you can't hear the other station when it answers. When you send, press the button. When you want to listen, release it.

You must not call the same station for more than 30 seconds at a time. If you do not get a reply, wait at least two minutes before calling again. After three calling periods, wait at least 15 minutes before calling again.

When the other station answers, immediately request that it switch to a working channel. Table 11-1 lists the channels you can use for the kind of message you wish to send. Know which channel you want to switch to before you call.

After you reach the other station, switch to a working channel and send your message. If you expect an answer, end your transmission with the word, "OVER." If you do not expect an answer, say "OUT." Do not say, "OVER and OUT." It has no meaning.

Be sure to identify your station by giving your FCC call sign at the beginning and end of each message. You must do this in English.

Keep your communication brief. When you are through, give your vessel's name and call sign. The other station also gives its name and call sign. After this, switch back to channel 9.

Public Correspondence Calls

If you want to place a telephone call, first turn your radio on. Next, switch to a Public Correspondence channel and listen to see if it is in use. Press the microphone button and say, "(Name of coast station, three times) THIS IS (your call sign)."

When the marine operator answers, say, "THIS IS (name of boat, call sign, and billing number assigned), PLACING A CALL TO (city and telephone number)." Tell the operator the type of billing you desire. Except for distress calls, there is a charge for the service from the company which owns the coast station.

Making Ship-to-Ship Calls Through a Coast Station

Although you usually make a call to another ship by calling it directly, you can do it through a coast station. You use the same procedure as you do for ship-to-shore calls. You might make such a call if the vessel you are calling is too far away for you to reach it. Remember, the coast station has a high antenna.

Making Shore-to-Ship Calls

To call a vessel from a shore telephone, you must know where the vessel is. You then dial "0" (zero) and ask the operator to connect you to or give you the phone number of the marine operator nearest the vessel. You will need to tell the marine operator the name of the vessel you are calling. If you know it, give the marine operator the call sign of the vessel's radio station. If the vessel monitors a channel or channels in addition to channel 9 give the operator that information.

Once connected with the vessel, remember that the ship station operates using a push-to-talk radio. Don't try to break in while the ship station is transmitting. Wait until you hear, "OVER." When you are through, hang up.

Limited Coast Stations

Limited coast stations serve the operational and business needs of vessels. Some, such as those operated by a harbor master or at a drawbridge, also serve a safety function. Limited coast stations are not open to public correspondence.

Yacht clubs with docking facilities, marina operators, boatels, dockside restaurants, marine police, towing services, and others operate limited coast stations. There is no charge for communications services incidental to their business.

Call a limited coast station on its working channel. If you can't reach it on its working channel, try channel 9. Be ready to switch to a working channel. A limited coast station calls vessels on channel 9 so you do not need to monitor its working channel if you are expecting a call.

PROCEDURE WORDS

A key to efficient use of radiotelephone time is the use of **PROCEDURE WORDS**, or "**PRO-WORDS**" for short. These words are a form of "shorthand." Table 11-2 lists some common prowords. You can see from the table how much they reduce transmission time.

Don't be sensitive about using prowords. No one will think you are showing off by using terms such as "**WILCO**" if you use them correctly.

Beware of other words in common use that sound like prowords. Although they sound like prowords, they accomplish nothing. For example, following several unanswered calls to a boat on channel 9, you may hear something such as, "Negative contact. This is XXXXX, out." This is meaningless. Anyone listening knows there was no contact. Worse still, the unnecessary announcement could have masked another call.

PHONETIC ALPHABET

When radio signals are weak and reception is poor, you may need to spell words or to express numbers in clear ways. The phonetic alphabet and its pronunciations appear in table 11-3. In use, the person sending the message says, "I spell." The phonetic spelling of a word or words follows. The proper use of the phonetic alphabet reduces misunderstandings.

Numbers

Closely allied to the phonetic alphabet is the manner of pronouncing numbers. In a message, if you spell out a number, you precede it by saying, "Figures...." The correct pronunciations of the numbers are in table 11-4.

If your vessel is in distress and you can't give its exact location, the Coast Guard may request that you make a "long count." During the count, the Coast Guard "homes" in on your signal with a radio direction finder to determine where you are. If the Coast Guard asks you to give a long count, say slowly, "WUN TOO THUH-REE FO-WER FI-YIV SIX SEVEN ATE NINER ZERO ZERO NINER ATE SEVEN SIX FI-YIV FO-WER THUH-REE TOO WUN." A short count goes from wun to fi-yiv, repeats fi-yiv and goes back down to wun.

ROUTINE RADIO CHECK

You can't tell if your radio is transmitting unless you talk to another station. Don't call the Coast Guard, though. It is illegal to ask them for a radio check on channel 16. Instead, direct your call to a station you know is operating. Don't send a general call for a radio check.

Begin your request on channel 9, then quickly switch to a working channel. Listen to see that channel 9 is not busy and call a specific station or vessel. Include the phrase "request a radio check" in your initial call. For example say, "MARY JANE (three times) - THIS IS BLUE DUCK - WHISKEY ALFA 1234 - REQUEST RADIO CHECK CHANNEL ____ (names a working channel) - OVER." Mary Jane replies on the working channel.

Mary Jane's response depends on how well your message was received. Appropriate responses are, "BLUE DUCK, THIS IS MARY JANE - WHISKEY TANGO 5678 - I HEAR YOU LOUD AND CLEAR," or "I HEAR YOU WEAK BUT CLEAR," or "YOU ARE LOUD BUT DISTORTED.""

Do not respond to a radio check with phrases such as: "I HEAR YOU FIVE BY FIVE," or "I READ YOU LOUD AND CLEAR." Such jargon has no place on VHF-FM radios. Using the term "read" implies a radio check by a meter. Also, don't use the 10-codes. There is no universal agreement on their meanings.

Table 11-2

Procedure Words (PROWORDS)

Procedure *Word*	Meaning
OUT	This is the end of my transmission to you. No answer is required or expected.
OVER	This is the end of my transmission and a response is expected. Go ahead, transmit. Omit when it is clearly not needed.
ROGER	I received your last transmission ok.
WILCO	Your last message has been received, understood, and will be complied with.
THIS IS	This transmission is from the station whose name and call sign follows immediately.
FIGURES	Figures or numbers follow, for example, "Vessel length is FIGURES two three feet."
SPEAK SLOWER	Your transmission is difficult to understand. Speak slower.
SAY AGAIN	Repeat.
WORDS TWICE	It is difficult to understand you. Give each phrase twice.
I SPELL	I shall spell the next word phonetically. Used when a proper name is important in the message. "Boat name is Martha. I spell–Mike, Alfa, Romeo, Tango, Hotel, Alfa.
WAIT	I must pause for a few seconds; stand by for further transmission.
WAIT OUT	I must pause for longer than a few seconds. I will call you back.
AFFIRMATIVE	You are correct, or what you have transmitted is correct.
NEGATIVE	No.

DISTRESS, URGENCY, AND SAFETY CALLS

If your vessel is in distress, you may use any means in addition to your radio to attract attention and get help. Often visual signals such as flags, flares, lights, and smoke or audible signals such as your horn or a whistle will get the attention and help you need.

If you can't use visual or audible signals, use your VHF-FM radio. Initiate your call on channel 16, but remember, you can use it or any other channel, including the public correspondence channels, to request emergency help.

Spoken Emergency Signals

There are three spoken emergency signals. They show the degree of severity of the emergency. All three signals are initiated on channel 16. Distress and urgency messages are then given on channel 16. Safety messages are given on a working channel.

Distress Signal—MAYDAY. The distress signal, MAYDAY, precedes a distress message about a grave and imminent danger and a request for immediate help. MAYDAY has priority over all other calls. MAYDAY comes from the French expression, "M'aider," which means "Help me." If you use it, speak the word three times, "MAYDAY, MAYDAY, MAYDAY."

Urgency Signal—PAN. The urgency signal, PAN, is pronounced PAHN and is said three times in groups of two, "PAN-PAN." It announces that an urgency message follows. PAN comes from the French word PANNE which means urgency. When you use it, say "PAN-PAN, PAN-PAN, PAN-PAN." Use the urgency signal when the safety of a vessel or person is in jeopardy. Only a distress signal has a higher priority.

Safety Signal— SECURITY. The safety signal announces a message about safety of navigation or an important weather warning. It is the French word SECURITY, pronounced SAY-CUR-EE-TAY and is said three times. Safety signals have higher priorities than any other messages except distress and urgency messages.

Table 11-3

The Phonetic Alphabet

Letter	Phonetic Equivalent	Pronunciation
A	ALFA	***AL***[1] FAH
B	BRAVO	***BRAH*** VOH
C	CHARLIE	***CHAR*** LEE
D	DELTA	***DELL*** TAH
E	ECHO	***ECK*** OH
F	FOXTROT	***FOKS*** TROT
G	GOLF	GOLF
H	HOTEL	HO ***TELL***
I	INDIA	***IN*** DEE AH
J	JULIETT	JEW LEE ***ETT***
K	KILO	***KEY*** LOH
L	LIMA	***LEE*** MAH
M	MIKE	MIKE
N	NOVEMBER	NO ***VEM*** BER
O	OSCAR	***OSS*** CAH
P	PAPA	PAH ***PAH***
Q	QUEBEC	KEH ***BECK***
R	ROMEO	***ROW*** ME OH
S	SIERRA	SEE ***AIR*** RAH
T	TANGO	***TAN*** GO
U	UNIFORM	***YOU*** NEE FORM
V	VICTOR	***VIK*** TAH
W	WHISKEY	***WISS*** KEY
X	XRAY	***ECKS*** RAY
Y	YANKEE	***YANG*** KEY
Z	ZULU	***ZOO*** LOO

[1] Emphasis is on the part of the word in ***bold italics.***

Most safety messages are initiated by the Coast Guard. These messages are announced on channels 9 and 16 and given on a Coast Guard working channel, usually channel 22A. If you have a safety message to send, announce it on channels 9 and 16 and give it on a working channel.

Any message headed by one of the emergency signals has priority over other messages. This means continue to listen but don't transmit. Be prepared to help if you can.

The decision about which emergency signal to use is the responsibility of the person in charge of the vessel. Sometimes there is no clear line to separate one from the other. Too, what started as a routine problem might develop into a serious one. Running out of gasoline is not an emergency. Running out of gasoline in a shipping lane may be an urgency situation. Running out of gas in a shipping lane with large ships headed toward you is more serious.

The Radiotelephone Alarm Signal

You may precede an emergency signal by a Radiotelephone Alarm Signal. The signal consists of two audio frequency tones sent alternately. The signal is similar in sound to the two-tone siren used by some ambulances. It lasts at least 30 seconds but not more than one minute. The purpose of the signal is to attract the attention of persons on watch or to start automatic devices giving the alarm.

The alarm signal announces that a distress signal will follow. It also can announce an urgency message about a person overboard when help is needed.

Sending a Distress Call

You send a distress signal and message on channel 16. During the emergency, do not switch to another channel. If you are being received on channel 16, don't risk the chance of losing contact by switching to another channel.

Fig. 11-5. A Coast Guard Communication Station

Table 11-4

Pronunciation of Numbers

Number	Pronunciation
0 ... ZERO	ZERO
1 ... ONE	WUN
2 ... TWO	TOO
3 ... THREE	THUH REE
4 ... FOUR	FO WER
5 ... FIVE	FI YIV
6 ... SIX	SIX
7 ... SEVEN	SEVEN
8 ... EIGHT	ATE
9 ... NINE	NINER

A distress call includes, if available, the Radiotelephone Alarm Signal. After this, send the following in order:

1. The distress signal MAYDAY spoken three times,
2. The words THIS IS spoken once,
3. Name of your vessel spoken three times and your call sign spoken once.
4. The distress signal MAYDAY spoken once,
5. The name of your vessel spoken once,
6. The position of your vessel either by latitude and longitude or by a bearing (either true or compass) and a distance from a well-known landmark. You can give it any way that will assist in locating you,
7. Nature of your distress, for example, taking on water, sinking, fire, etc.,
8. Kind of help needed,
9. Any other information that might help. This might include the length or tonnage of your vessel, the number of people on board, and the number of people needing medical attention. It helps to give a description of your vessel including the color of its hull, deck, cabin, masts.
10. When you are through say, "I WILL BE LISTENING ON CHANNEL 16."
11. End your message by saying, "THIS IS (your boat name and call sign), OVER."

Release the microphone button and listen. Someone should answer. If you do not receive an answer, repeat your call beginning at item 1, above.

To help you recall the above steps in an emergency, refer to table 11-5. Copy it, fill it in except for items 6 through 9, and post it near your radio.

Acknowledging a Distress Message

If you hear an unanswered distress message, you *must* answer. Your reply is sent on channel 16. If you are reasonably certain that the distressed vessel is not in your vicinity, you should wait a short time for others to acknowledge. Wait, also, where there are reliable communications with the Coast Guard.

After you acknowledge receipt of the distress message, wait a short time. There may be others in a better position to help than you are. They should also acknowledge receipt.

When you are sure you are not interfering with other distress related communications, contact the vessel in distress and tell them what assistance you can give. If the vessel is in your area, you are obligated to render any possible assistance. Make sure the Coast Guard knows about the distress. Relay the distress message to the Coast Guard if necessary.

If you can't reach the Coast Guard directly, call the nearest marine operator. This is especially important if the distressed vessel is beyond reach of the Coast Guard and you are between the Coast Guard station and the distressed vessel.

You acknowledge receipt of a distress message by saying the name and call sign of the distressed vessel three times. Follow this by saying, "THIS IS" and your vessel's name and call sign. Do this three times then add, "RECEIVED MAYDAY."

After a momentary pause to ensure that you are not interfering with a vessel better situated to help, send the following: Start with the proword, "MAYDAY." Then give the name and call sign of the distressed vessel. Continue with, "THIS IS" and give your vessel's name and call sign. Tell where you are, your speed, and how much time it will take you to reach them.

A vessel or shore station that learns that a vessel is in distress shall send a distress message when the vessel in distress can't send the message itself. It may also do it if more help is needed. If it hears an unacknowledged distress message and is not able to assist, it sends a distress message.

In such a case, the transmission consists of the Radiotelephone Alarm Signal (if available) followed by "MAYDAY RELAY MAYDAY RELAY MAYDAY RELAY." You then say, "THIS IS" and give the name and call sign of your vessel or shore station three times. If you send a distress message under these conditions, contact the Coast Guard.

Imposing Silence

The vessel in distress or the station in control of distress communications may impose silence on any station that interferes by sending, "SELONCE MAYDAY." ("selonce" is the French pronunciation of the word "silence.") Any other station that believes it essential may impose silence by sending "SEELONCE DISTRESS" followed by the name and call sign of the station imposing the silence.

After distress communications have ceased, or when silence is no longer necessary, the station in control ends the silence. It does so on channel 16 by sending the following: "MAYDAY," "TO ALL STATIONS TO ALL STATIONS TO ALL STATIONS," "THIS IS," "(name and call sign of station ending the distress), (the time), (name and call sign of vessel in distress), SEELONCE FEENEE." SEELONCE FEENEE is the French pronunciation of Silence Finis meaning Silence Finished.

Radiotelephone Station Log

A radio log is a record of calls made and received by a station. Each page of a radio log should be numbered, have the name of the vessel and call sign, and be signed by the operator. Entries should show the time each watch began and ended using 24-hour military time.

If your boat is less than 65 feet long, you do not have to keep a radio log. You must, however, record as completely as possible all emergency signals and communications you hear. You must keep this log for at least three years. Keep it for a longer time if it concerns communications under investigation by the FCC or against which claims or complaints have been filed.

Table 11-5

Distress Communication Form

Instructions: Complete this form now (except for items 6 through 9) and post near your radiotelephone for use if you are in distress.

SPEAK: SLOWLY - CLEARLY - CALMLY

1. Make certain your radio is turned on.
2. Select **VHF-FM Channel 16** or **2182 kHz for your SSB.**
3. Press microphone button and say: **MAYDAY--MAYDAY--MAYDAY.**
4. Say: **THIS IS** ______________________________
   (Your boat name, repeated three times, and your call sign.)
5. Say: **MAYDAY** ______________________________
   (Your boat name)
6. **TELL WHERE YOU ARE.** (What navigational aids or landmarks are you near? What direction and distance are you from a landmark? What is your latitude and longitude? What are your Loran coordinates?)
7. **STATE THE NATURE OF YOUR DISTRESS.**
8. **GIVE NUMBER OF PEOPLE ABOARD AND CONDITIONS OF ANY INJURED.**
9. **ESTIMATE CURRENT SEAWORTHINESS OF YOUR BOAT.**
10. **BRIEFLY DESCRIBE YOUR BOAT:** ______________ **FEET;** ______________;
    (Length) (Type)
    ______________HULL; ______________TRIM; ______________MASTS;
    (Color) (Color) (Number)
    ____
    (Anything Else You Think Will Help Rescuers Find You.)
11. Say: **I WILL BE LISTENING ON CHANNEL** ______ 16/2182. ______
    (Cross Out One Which Does Not Apply)
12. End message by saying: **THIS IS** ______________________________. **OVER.**
    (Your Boat Name and Call Sign)
13. Release microphone button and listen. Someone should answer. **IF THEY DO NOT, REPEAT CALL, BEGINNING AT ITEM #1, ABOVE. IF THERE IS STILL NO ANSWER, CHECK TO SEE IF YOUR SET IS TURNED ON, IS ON HIGH POWER, AND IS ON CHANNEL 16 IF IT IS VHF-FM OR 2182 kHz IF IT IS SSB.**

RADIOTELEPHONE STATION LOG

Vessel Name: ____________________ Vessel Call Sign: ______________________________ Page # ______

Date	Local Time Symbol		Channel or Frequency Used	Station Called or Calling	Message	Operator's Signature
	Time Begun	Time Ended				

Fig. 11-6. Radiotelephone Station Log

Urgency Calls

You also send urgency signals and messages on channel 16. Precede the message by the emergency signal “PAN-PAN” spoken three times. Use the urgency signal and message in situations such as the following:

- Loss of a person overboard, but only when help is needed,
- Repeating an urgent storm warning from an authorized shore station,
- Loss of steering or power in a shipping lane.

Sending an Urgency Call

The urgency signal and message usually include the following:

1. The urgency signal PAN-PAN spoken three times,
2. “TO ALL STATIONS” (or a particular station),
3. The words, “THIS IS,”
4. Name of your vessel spoken three times and your call sign spoken once,
5. The urgency message (describe the problem),

6. Position and description of your vessel and any information that will help responding vessels,
7. The words, "THIS IS,"
8. The name of your vessel and its radio call sign spoken once,
9. The proword, "OVER."

Sending a Safety Message

The safety signal, "SECURITY," precedes a safety message. You send it on channels 9 and 16. Here is an example of a safety message from the Barbara Ann that has the radio sign WX 3456. "SECURITY, SECURITY, SECURITY. THIS IS BARBARA ANN, WHISKEY XRAY 3456. SHIFT TO CHANNEL (local working channel) FOR SAFETY MESSAGE. THIS IS BARBARA ANN, WHISKEY XRAY 3456. OUT."

On the working channel the message might be: "SECURITY, SECURITY, SECURITY. THIS IS BARBARA ANN, WHISKEY XRAY 3456. A LOG APPROXIMATELY 20 FEET LONG, 2 FEET DIAMETER IS ADRIFT OFF HAINES POINT IN THE POTOMAC RIVER. THIS IS BARBARA ANN, WHISKEY XRAY 3456. OUT."

Many skippers prefer to contact the Coast Guard and let them give the security call.

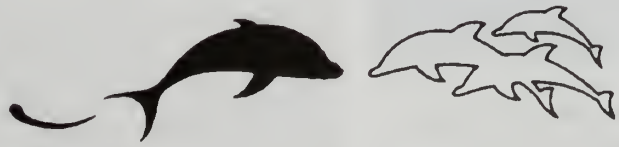
CREW TRAINING

More than one person on board should know how to operate your vessel and your radio. Give your guests a brief introduction to your radio when you describe your vessel's operation and safety features. Fill out the form in table 11-5 and post it so that anyone on board can summon help in an emergency.

This may seem too cautious. Many emergencies could have had better outcomes, though, if someone aboard other than a stricken skipper, knew how to operate the radio or start the boat's engine. Many emergency broadcasts did not summon help because the rattled operator did not turn on the power, or called on the wrong channel, or forget to depress the press-to-talk button. Others have failed because the squelch was too high or the press-to-talk button wasn't released and the return message wasn't received.

AN INVITATION

If you would like to learn more about radio communications, consider joining the Coast Guard Auxiliary. We have an advanced course for our members.



12

Inland Boating

> **The face of the water, in time, became a wonderful book—a book that was a dead language to the uneducated passenger, but which told its mind to me without reserve, delivering its most cherished secrets as clearly as if it uttered them with a voice. And it was not a book to be read once and thrown aside, for it had a new story to tell every day. Throughout the long twelve hundred miles there was never a page that was void of interest, never one that you could leave unread without loss, never one that you would want to skip, thinking you could find higher enjoyment in some other thing.**
>
> —Mark Twain, *Life on the Mississippi*

Many boaters spend their time on the open seas, the gulfs, and other tidal waters. Even more are inland boaters.

TYPES OF INLAND WATERS

Inland boaters use rivers, lakes, and canals. Each of these waters offers varied experiences and challenges.

Rivers

There are over 30,000 miles of **NAVIGABLE RIVERS** in the United States. These include the Western Rivers and the Tennessee-Tombigbee Waterway (the Tenn-Tom), the Tombigbee, Black Warrior, Alabama, Coosa, Mobile, Flint, and Chattachoochee Rivers, and the Apalachicola River above its confluence with the Jackson River. The Western Rivers, as dis-

Fig. 12-1. The inland waterways can provide some of the most beautiful boating areas to be found anywhere. (North Arm of Lake Minnetonka, Minnesota)

cussed in chapter 6, include most of the Mississippi and all of its tributaries such as the Missouri, Ohio, Wabash, Green, and Barren Rivers.

NAVIGABLE WATERWAYS include navigable rivers, the Great Lakes, and the Intracoastal Waterway. Besides the navigable waterways, there are other rivers used by pleasure boaters and people hunting or fishing.

Rivers range in size and character from the wide Missouri and the muddy Mississippi to small and meandering streams such as the Sipsey and the Cahaba in Alabama. They range also from fast moving streams such as the Snake River between Idaho and Oregon to slow ones such as the Illinois. Each offers its pleasures and challenges.

Lakes

Lakes present as much variety for boaters as rivers do. There are large, natural lakes such as the Great Lakes and Lake Okeechobee. There are also large artificial lakes, such as Lake Meade in Nevada and Lake Sidney Lanier in north Georgia. In between are long, artificial "lakes" made by damming streams and created for commerce, generation of electricity, irrigation, water supply, and flood control. Besides the large natural and artificial lakes, there are small lakes and farm ponds used by boaters including those who fish and hunt.

Canals

Canals are also inland waterways. They serve important navigational purposes. For example, the Sault Ste. Marie canals connect Lakes Superior and Ontario and bypass the rapids on St. Mary's River. The New York State Barge Canal is a waterway system 525 miles long that connects the Great Lakes, Lake Champlain, and the Hudson River.

The Chesapeake and Delaware Canal is 19 miles long and runs between the head of Chesapeake Bay and the Delaware River. The Tennessee-Tombigbee waterway (the Tenn-Tom) makes it possible to go from the Tenneessee River to the Gulf of Mexico by way of the Tombigbee and Mobile Rivers.

Watch Your Speed

Artificial waterways are usually narrow. This means that boaters must be especially aware of the effects of their boats' wakes on other boats and on the waterway. Although the Tenn-Tom opened only in the 1980s, wakes have caused serious erosion of its banks and partial blocking of its channel.

Many canals have restricted speeds to reduce wakes. Heavy wakes in narrow waterways echo from the shores several times and create considerable turbulence. Reduced speed is also necessary because of heavy commercial traffic. If you use one of these waterways, yield to barges and other commercial traffic. They are dangerous.

INLAND NAVIGATION

Although the inland waters are diverse, they require many of the same skills and knowledge needed for boating on tidal waters. They also require skills and knowledge different from that needed on tidal waters. Knowledge of radio communication, marlinspike seamanship, boat construction, engines, boat handling, and other subjects can serve you as well on inland waters as on tidal waters.

Inland Navigation Rules

The Inland Navigation Rules are in force on navigable waterways. They do not apply on non-navigable lakes and streams that are entirely within a single state although state and local regulations may be in effect. Even if the Inland Rules are not in force on a body of water, common sense dictates that you should follow them whenever possible. They reflect a large body of experience in avoiding collisions.

The need for a lookout on a lake, for example, is as great as on any other body of water. Meeting, crossing, and passing situations are as dangerous on lakes as anywhere else. Proper lighting of vessels at night is important wherever boating occurs. The rules help boaters avoid collisions. Do your best to observe them.

Where the Inland Navigation Rules apply, the equipment requirements listed in chapter 2 also apply. Safety practices apply equally on inland and international waters. On large bodies of water such as the Great Lakes and Lake Okeechobee, piloting principles apply.

Inland ATONs

Two ATON systems are in use on inland waters. One of these marks navigable rivers and is similar to the U.S. ATON system. The other marks waters solely within the control of a state.

Western Rivers ATONs

The ATONs that appear in the upper part of Plate 4 in the appendix to this book are used on the Western Rivers. They are used also on the other navigable rivers listed earlier in this chapter. The Coast Guard installs and maintains them.

Inland rivers ATONs differ little from those used in the U.S. ATON system and described in chapter 5, Your "Highway" Signs. Red daybeacons, lights, and buoys mark the starboard banks and limits of channels as vessels "return from sea" or proceed upstream. Green daybeacons, lights, and buoys mark the port banks and limits of navigable channels when going upstream.

River Bank Names. The banks of rivers have names. They are "left" and "right." As you travel downstream, the bank on your right is the right bank and that on the left the left bank. *The right bank has green ATONs and the left bank has red ATONs.* Thus, the west bank of the Mississippi is its right bank and it has green ATONs.

To avoid confusion, commercial river traffic often calls the right bank the right descending bank and the left bank the left descending bank. Expressed in this way, it leaves no room for doubt in your mind.

One difference between the U.S. ATON system and the Western Rivers System is that the Western Rivers System does not use safe water marks. They would not serve a useful purpose on a river.

Passing Daymarks. In the Western Rivers System, triangular and square **PASSING DAYMARKS** mark the rivers' banks. If you see a triangular red or square green daymark on the bank you know that the channel is on that side. You continue past it since it is a *passing daymark*.

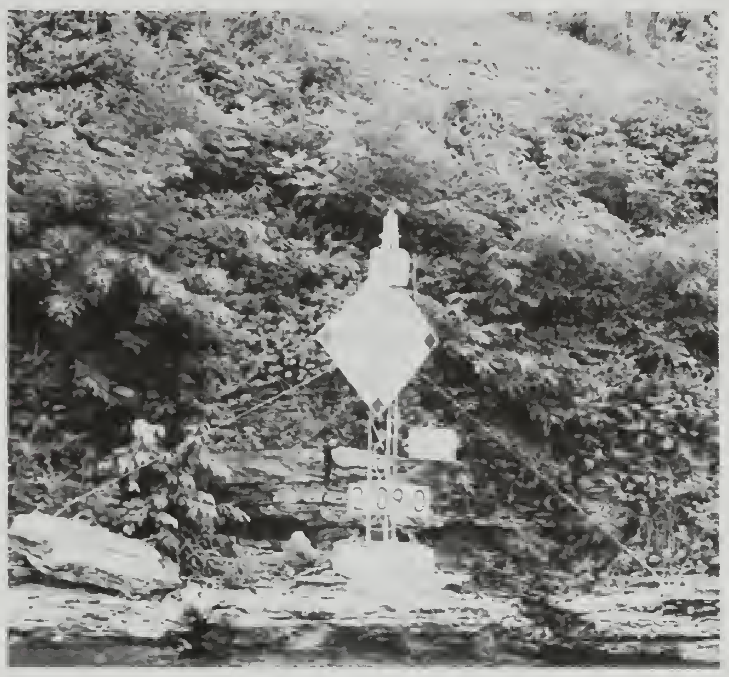


Fig. 12-2. A Crossing Daymark

Crossing Daymarks. Because the navigable channels of rivers swing from bank to bank as the rivers bend, the Western Rivers System uses an additional daymark to assist river traffic. **CROSSING DAYMARKS** help you know when the channel has changed from one side of the river to the other. Daymarks, buoys, and minor lights help you know where the channel is.

Using Crossing Daymarks. The diamond shaped crossing daymarks are always on the opposite side of the river from where you are until you cross over. They show that the channel has crossed over to the other side. Thus, the diamond shaped daymarks are crossing daymarks. You should head for the diamonds!

As you pass a daymark, look back at it. If it has a crossing daymark on its back, you know that the next daymark will be a crossing daymark and that it will be on the opposite side of the river. The crossing daymark that you see on the back of a passing daymark is there to guide a vessel travelling in the opposite direction. Looking back at a passing daymark to see a crossing daymark is particularly helpful at night or in reduced visibility when the bend in the river may not be visible. It is also easier to spot a green crossing daymark on the opposite bank when you are expecting to find it there.

When you see a crossing daymark, it tells you nothing about what the next daymark will be. It could be a passing daymark or it could be another crossing daymark on the opposite side of the river. Again, look at the back of the crossing daymark you are passing.

Plate 4, shows that crossing daymarks are either green or red. In each corner there are small diamonds made of reflective material that makes them easier to locate after dark. Green passing and crossing daymarks are always on the right descending bank while red ones are on the left descending bank.

When you look back and see a green crossing daymark, you know that the next daymark will be on the opposite side of the river, and it will be a red crossing daymark. Similarly, when you look back and see a red crossing daymark, you know the next daymark is a green crossing daymark and on the opposite side of the river.

River Buoys. Changes in river channels caused by fluctuations in water level, current speed, and shifting shoals make buoy maintenance a continuous task for the Coast Guard. It frequently adds buoys or takes them out of the system. In wintertime where rivers freeze, buoys are lost or moved from position. Because of their somewhat temporary nature, river buoys do not have letters or numbers and are not usually shown on river charts.

Mile Markers. Some of the most useful markers on a river are the **MILE MARKERS**. These are placards attached to daymarks or displayed in other easily seen places. Since the U.S. Corps of Engineers erects them, they show distances in statute miles rather than nautical miles as would be expected from a corps of the land-based U.S. Army.

With the exception of the Ohio river, mile markers tell you how far it is to the mouth of the river. Ohio river markers start at its headwaters and tell you how far downstream you are. Mile markers help you to locate your position on a river chart. They also help you to know which passing and crossing daymarks you are looking at.

Piloting Tools. There are important differences in river and coastal piloting. For instance, you seldom need to plot a compass course or to maintain a dead reckoning plot on a river. You can tell where you are by using a chart of the river and noting the mile markers.

Besides local knowledge and a chart of the river, the river navigator will find that the most useful piloting tool is a good binocular. It is useful for reading mile markers and locating ATONs.

Uniform State Waterway Marking System

States mark some of their exclusively state waters with markers from the Uniform State Waterway Marking System (USWMS). At times they also place these markers on federal navigable waters. The lower part of Plate 4 in the appendix to this book shows these marks. They consist of regulatory markers, aids to navigation, and mooring buoys.

Regulatory Markers. Regulatory markers are of two types, signs or buoys. Both the buoys and signs are white. The signs have orange borders and orange symbols. Buoys are white with an orange band near the top and a second band near the water's surface. They also have orange symbols. Where letters or numbers appear on the signs or buoys, the lettering is black.

Regulatory markers show boat exclusion, danger, and controlled areas. They also give information or directions. Examples of exclusion areas are areas near dams, rapids, and swimming places. Exclusion area markers have orange diamonds with diagonal marks. They also show the nature of the area in black letters.

Danger area markers have open diamonds. The nature of the danger may appear in black letters. Controlled area markers have orange circles with the nature of the warnings printed in black letters.

USWMS ATONs. ATONs in the USWMS are buoys. These are of two types, lateral markers and cardinal system markers. Lateral markers show the lateral edges of channels and are solid black or solid red. Each buoy has a white number. Black buoys may have green reflectors or lights. Red buoys may have red reflectors or lights. The buoys usually occur in pairs which means that the safe passage is between them. If the channel is in a stream, red buoys mark the starboard side of the channel for boats moving upstream and black buoys mark the port side.

The cardinal system is used on lakes where the concept of "returning from sea" is meaningless. The system uses three different kinds of buoys. These buoys mark safe passage areas. A red-striped white buoy tells you not to pass between it and the nearest shore. This buoy may have a letter on it. A white buoy with a black top means that you should pass to the North or East. A red-topped white buoy tells you to pass to the South or West. Any of these buoys may have white reflectors or lights. The black-topped and red-topped buoys may have numbers.

The USWMS also includes mooring buoys. These are white buoys with blue bands. They may show white reflectors or lights. You may tie up to these buoys.

INLAND SEAMANSHIP

One difference between inland and salt water boating is the constantly changing nature of the inland waters. Salt water boaters expect the tidal changes that come with predictable regularity. They prepare for them and take them into account while maneuvering and mooring.

Changing Water Depths

Although some inland waters differ little from day to day, they are the exception rather than the rule. Mark Twain's quotation from *Life on the Mississippi* emphasizes the point that rivers are ever-changing. One important feature of this change is the wide range in water depth that occurs in some streams. Another is the speed of their currents.

Rivers and impounded waters vary in depth from season to season and day to day according to the amount of rainfall or melting snow in the area or upstream. Rivers can rise up overnight and overflow their banks. They can experience droughts and sink to mere rivulets. They can turn from sluggish streams to torrents.

The Mississippi River depth at Memphis varies almost 50 feet during an average year; daily changes may be well over a foot. This means that at times navigators must use narrow channels while at other times they have considerable freedom of movement. Continuous monitoring of river channels' depths is necessary to aid commercial traffic. In many locales, newspapers give daily reports on river and lake levels.

Many rivers have depth gauges posted at important points such as bridges and locks. Some of these gauges note whether the river is rising or falling. Figure 12-3 depicts two of these gauges.

Lake Hazards

Much of what this chapter says about river boating and its hazards also applies to lakes, especially if the lakes are impounded waters. Water levels vary from season to season and with local precipitation. The water levels of some impounded lakes vary in response to flood control efforts upstream, and to the needs for electrical power, irrigation, and community water supplies.

During high water, boaters should beware of overhead power lines that are not normally over the lakes and for lower clearance below

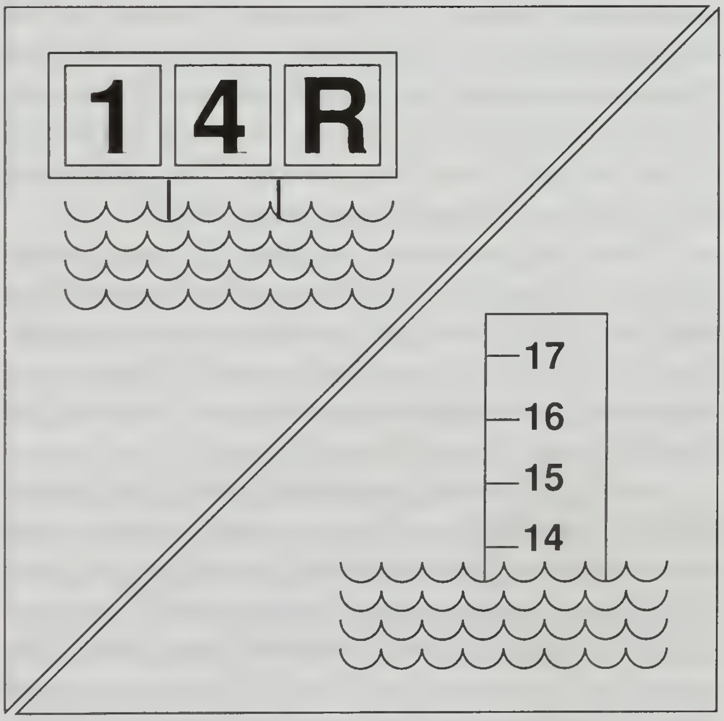


Fig. 12-3. River "stages" are noted on gauges up and down many rivers. The river's level and whether the river is rising or falling may be displayed on signboards.

lines that cross the lakes. Sailboaters should be especially cautious.

Underwater Hazards

If the lake's purpose is to control flooding, the engineers may have cleared vegetation only from the shoreline of the normal pool. Entire trees may remain standing, some with their tops close to the water's surface. In agricultural areas, fences and the remains of farm buildings may lurk just below the surface. These objects are closer to the surface when the water level is low.

High water may submerge picnic tables and barbecue grills in recreational areas. It may be difficult to get to the shoreline for a landing. Rocks and shoals which are not problems during normal water levels may become hazardous in low water.

In some small reservoirs, and especially downstream of dams, water levels can vary with dangerous speed and little warning. Heed posted warning signs and use extra caution when boating in these areas. Local knowledge is very important.

Other Lake Hazards

Lake boating is also subject to other environmental hazards. The water in spring-fed lakes can be very cold, even in summer. Hypothermia can develop rapidly if you fall overboard. Treelined shorelines or high cliffs and hillsides may block the horizon so you do not notice approaching severe weather.

The long, narrow profiles of many lakes serve to channel wind down the lakes. High wind in a shallow lake can create severe water turbulence. Be prepared when you round a bend or cross the mouth of a tributary—wind speed and direction may change abruptly.

Anchoring may be a problem in lakes due to debris on the bottom. Submerged logs and rocks can easily foul your anchor. A trip line is good insurance where there is much debris. Because water levels change rapidly in some lakes, it is possible to anchor in a small cove overnight and to find yourself aground the next morning. On the other hand, if you beach your boat for the night, you may find it downstream the next morning.

Services and Facilities

Marinas, fuel, "pump out," and repair facilities are scarce on the inland waterways and lakes. Overnight anchoring is the rule. The byword is *planning*. If possible when planning a trip, get the telephone numbers of facilities along the way. Learn their capabilities ahead of time. You may need to deal with a local service station for fuel and repairs or to visit a grocery store ashore for supplies.

Many lakes are far from towns and emergency responses may be slow. The Coast Guard and the Auxiliary often do not have search and rescue capabilities on remote lakes. Boaters will need to rely on park ranger's and sheriff's rescue teams. Know how to contact emergency services before you go! A cellular telephone may be invaluable.

RIVER CURRENTS

Most rivers have currents—sometimes very strong ones. These can pose major problems for both recreational and commercial boats.

River Channels

The river channel is the deepest part of a river. In a way, it is a river within the river. When a river basin floods, either naturally or because of dams, the channel may be lost under the broader river. Since the river may be very shallow outside the channel, vessel traffic must know where the channel lies. This is not easy to do since the channel may meander from bank to bank.

Where charts are available they can help you locate the channel. Aids to navigation mark the channels on inland rivers where traffic must stay within them.

The river's channel is also the point of concentration of the river's current. This can be a concern for riverboaters. Currents in the Mississippi and other rivers reach velocities of 8 to 10 or more miles per hour. Vessels moving upstream against the current may be making considerable speed through the water while making little progress over the ground. Some low-powered motorboats and sailboats may be unable to make headway upstream.

The current aids movement downstream. It boosts both speed and fuel economy. This economy has its drawback, though. A vessel carried downstream by a strong current loses some control and is more at the mercy of that current. For this reason, the Navigation Rules give the right-of-way to vessels headed downstream.

Behavior of Currents

River currents can be complex as the flow of the river responds to changes in channel direction and the shape of the bottom. The current at one depth may run counter to that at another depth. Deep draft vessels may experience a current moving in one direction while shallow draft vessels are experiencing a current moving in the opposite direction. Knowledge of these currents is useful to the boater. You can gain such knowledge through experience and by consulting knowledgeable boaters.

River Bends

The current usually flows around the outside of a river bend. This causes water to pile up on the outside. Because it has a higher head, this water flows faster than water on the inside of the bend. If it moves fast enough, it scours the channel and sweeps silt downstream. Thus, the water usually moves most rapidly and is deepest on the outside of a bend.

On the inside of a bend, where the current moves more slowly, the river deposits silt and shoaling may occur. Because of the difference in the speed of flow on the inside and outside of a bend, eddies and slack water often occur.

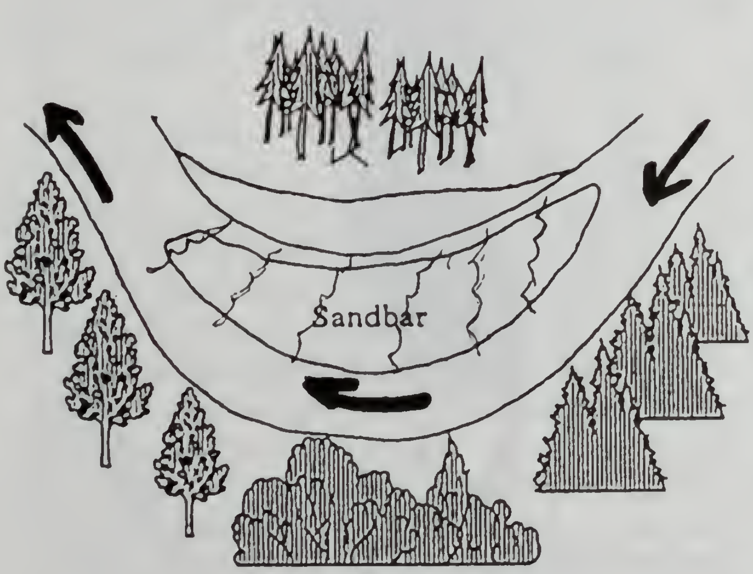


Fig. 12-4. In bends, the current flows along the outside bank. Slower-moving water on the inside allows silting and the formation of sand bars.

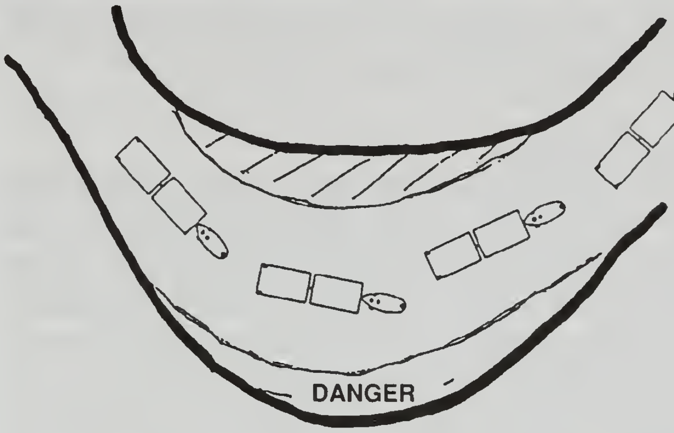


Fig. 12-5. Do not pass a tow on the outside of a bend. The tow will swing to the outside, the actual path of travel may be very different from the apparent heading of the vessel.

Vessels headed upstream sometimes move to the inside of a bend where the current is weaker or where it may reverse itself and head upstream. If you do this, you must be careful to avoid running aground. It is good practice to swing wide around points since their underwater extension may be farther out into the stream than you know.

If you round a bend that obscures your view, sound the bend signal. This is one prolonged blast (four to six seconds) on your whistle. If another vessel is entering the bend from the opposite direction, it should return your signal.

Entering a Current

The effect of a current may be considerable when you enter the main channel from a secondary one. Larger vessels and commercial traffic such as tows of barges must anticipate the impact of the change in current. When rounding a bend, tows must use the current as an aid in maneuvering. You should be ready to respond to the radical and rapid heading changes tows make as they negotiate bends or channel crossings. Tows are like trucks that carry signs saying, “This vehicle makes wide turns.” You may suddenly find yourself in the path of the tow.

If you run into trouble, try to maneuver out of the channel and away from commercial traffic. Then set an anchor and maintain a lookout until help arrives. If you can't get out of the channel, be prepared to warn commercial traffic of your plight by your VHF-FM radio or by visual signals (see chapter 6).

River Debris

During periods of high water, debris that has collected on river banks floats off. This debris consists of brush, tree stumps, entire trees, and trash that people have discarded. You can usually tell if a river is rising by noticing the amount of debris that is floating downstream. As a river crests and the water level begins to lower, less debris is present. While the debris is moving and after it is deposited, it is a danger to boat traffic and can seriously damage small recreational vessels.

In the spring of the year, rising water may break apart sheets of ice that have formed on the northern reaches of rivers. These ice floes may travel hundreds of miles downstream before melting. They are a threat to boat traffic both moving and moored.

When the water level in a river drops, it leaves debris in the path of boating traffic. Often the debris is just below the surface. Boaters should heed Mark Twain's advice and watch for subtle disturbances on the water's surface that may show that hazards lurk below. Learn to "read" the water.

MAINTAINING INLAND WATERWAYS

Rivers are like living and growing organisms. They change continuously. Channels may change in depth and location. During flood periods, a river may even change its course at some places. Because of this, channels must be monitored and controlled continuously.

The maintenance of the navigable waterways is the responsibility of the United States Corps of Engineers (the Corps). Its charge includes containing the wayward streams of the system, maintaining navigable channels, and ensuring channel depths wherever possible. This last charge is a difficult one in some waterways, especially in times of severe drought.

Levees

Rivers flood and may change their courses. Course changes are serious problems on many rivers, including the Mississippi, which cuts across bends and shortens its length when unconstrained. Unless some rivers are controlled, river towns can find themselves far from their rivers and without river fronts following a flood. To control flooding and wandering and to provide a navigable channel, the Corps maintains systems of levees on major rivers.

At bends in a river, the Corps uses **REVETMENTS** to protect its embankments. A revetment is a facing of stone, concrete, or other material. Revetments keep a river from cutting through its embankments and shortening its course.

Other Devices

For recreational boaters, a more important function of the Corps is its maintenance of navigable channels. It does this by using **DIKES** or **WING DAMS** built out from the shore toward a river channel. Local people sometimes call them "the works" or some other local name. They slow the water flow outside the channels. Silt and sand then accumulate around the dams rather than in the channel.

Directing a River's Flow

Wing dams and dikes also direct the flow of a river to the center of a channel. This speeds

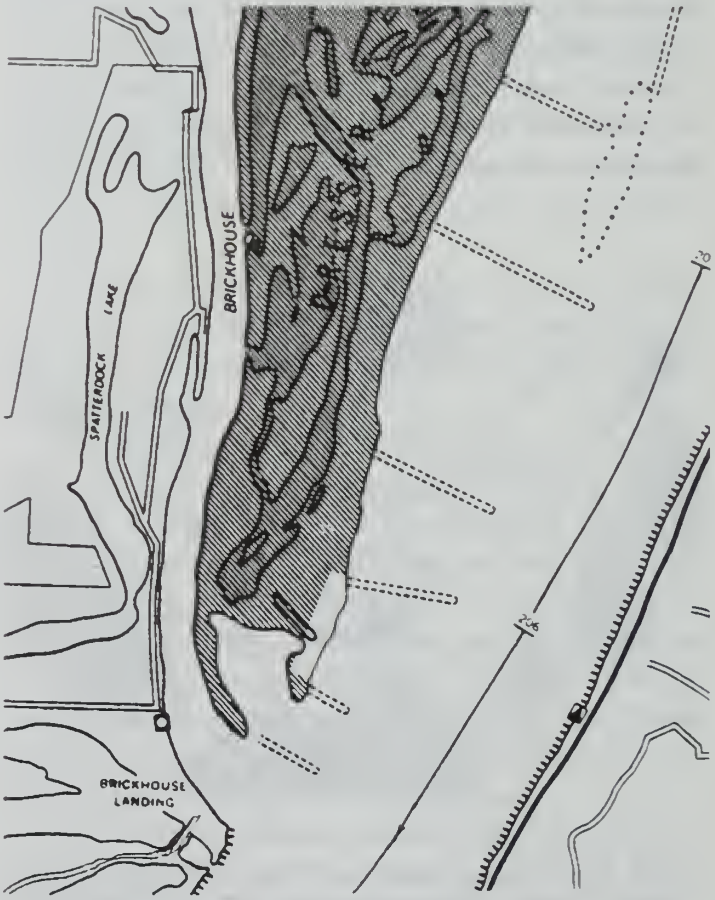


Fig. 12-6. Wing Dams On a River Chart

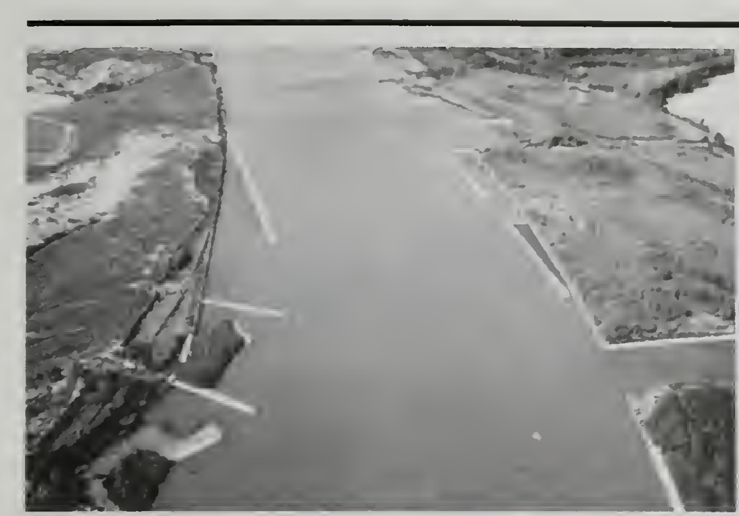


Fig. 12-7. Aerial View of Wing Dams On a River.

up the flow in the channel and cleanses it of silt and sand which helps to maintain its depth.

On some navigable rivers, the tops of many wing dams are above water but many are not. As originally constructed, the tops of most were above water but dams on the rivers raised the water levels in the pools above them and submerged many of the wing dams. About 95 percent of the wing dams in the Rock Island, Illinois, District of the Mississippi are below the water's surface all the time. Today, some wing dams have tops about three feet below the water's surface at normal pool.

There are about 1,200 wing dam structures on the Mississippi. Most of these were built between 1900 and 1927 to maintain 4.5 to 6 feet channels. Today these depths are too shallow for much commercial traffic so higher dams have been built. The old wing dams are still there and are often hazards for boaters.

Other Underwater Structures

Wing dams are not the only underwater structures that you must avoid. Often, the Corps removed only the channel sections of low dams when it built higher ones. The rest of the low dams remain as hazards.

Wing dams provide calm, overnight anchorages but submerged ones present problems for boaters. There may not be enough clearance above them to permit the passage of even recreational boats. In the daylight, turbulence may show their presence but this disappears at night. If river charts are available for where you boat, consult them.

Dredging

Wing dams seek to "train" the river into channels. They control the amount of silt and sand that a river deposits. Even so, silt and sand deposits become problems and it becomes necessary to dredge the channels. For example, in an area below Keithsburg, Illinois, it was necessary for the Corps to dredge the river 27 times in 25 years. During that period, the channel was lost several times and closed once. The Corps built wing dams in 1985. Since then, the area has needed dredging only once.

Dredges present problems for boaters. A dredge pumps large volumes of water containing silt and sand. A long pipe carries this mixture and discharges it ashore, on a "spoil bank," or into a barge. In the daytime it is easy to see the dredge. It is also easy to see the pipeline if it is floating or supported on a trestle.

Lights on Dredge Pipelines.

At night, pipelines that are floating or supported must have a row of yellow lights that flash 50 to 70 times per minute. These lights must be from 1.0 meter to 3.5 meters above the water and must clearly mark the length and course of the pipeline. The lights must be equally spaced and not more than 10 meters apart where the pipeline crosses a navigable channel. There must be two red lights at each end of the pipeline, including the ends in a channel where the pipeline is separated to allow vessels to pass.

Dredge Lights and Shapes.

Knowing on which side of a dredge to pass is not a problem when it is properly marked (see fig. 12-8). The Inland Navigation Rules require dredges to carry three shapes in a vertical line during the daytime. The highest and lowest of these shapes are balls and the middle one is a diamond. At night it carries three all-round lights in a vertical line. The highest and lowest of these lights are red and the middle one is white. These lights and shapes tell you that the dredge is restricted in its ability to maneuver.

The dredge also carries shapes and lights to tell you where the discharge pipe is. Two balls in a vertical line in the daytime or two red lights at

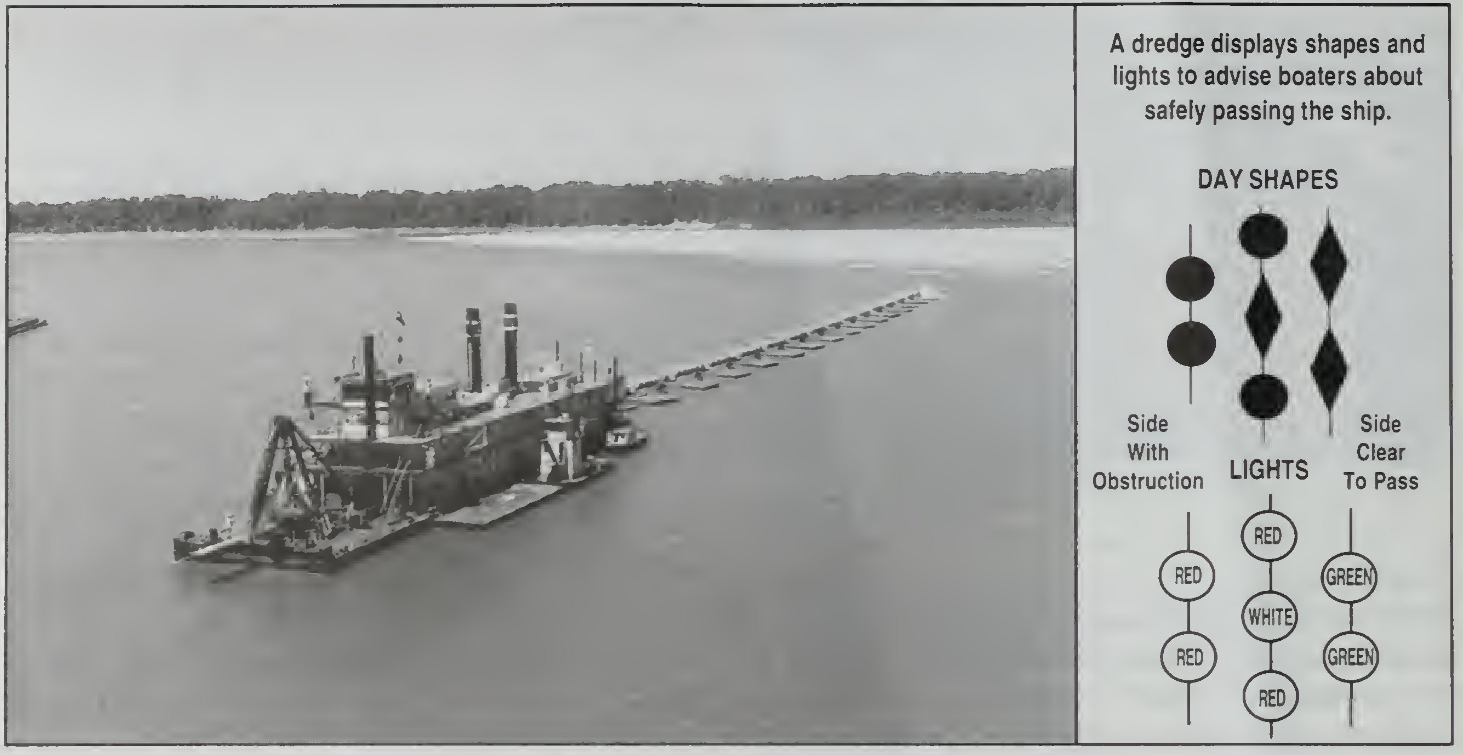

A dredge displays shapes and lights to advise boaters about safely passing the ship.
DAY SHAPES
Side With Obstruction
LIGHTS
Side Clear To Pass
RED
RED
RED
WHITE
RED
GREEN
GREEN

Fig. 12-8. Dredging Operation on the Rivers
(Photo Courtesy of Corps of Engineers)

nighttime tell you that the pipe is on that side. The side on which you should pass has two green lights or two diamonds in a vertical line. In the daytime, "Go for the diamonds."

DAMS

Over the years, many dams have been built on the inland waterways. Some serve to maintain navigable water depths for commercial boating traffic. Others provide water for communities, irrigation, mills, and electrical generation. Some are for flood control.

Dams are seldom, if ever, constructed for recreational boating although this is often a result. Their imposing powerhouses, spillways, and locks are intimidating to many boaters.

Lowhead Dams

On many small rivers, dams are simply low walls of concrete or stone that remain submerged most of the time (figs. 12-9 and 12-10). Officially they are "fixed-crest, low-level dams" but are often called **LOWHEAD DAMS**. They may be the most dangerous type of dam for boaters. They have been described as "efficient, self-operating drowning machines."

Lowhead dams vary in height from about one foot to several feet. They occur frequently in some areas. There are about 2,000 lowhead dams in the Commonwealth of Pennsylvania. Many serve to impound water for mills. Others provide minimum upstream water levels for water supply systems.

Passing Over Lowhead Dams

Because the drops over some of these dams may appear small, boaters sometimes assume that they can safely pass over them. Other boaters may not know that they are near one of these dams and may accidentally pass over them. If the water level is high enough, this is possible but boaters should realize that ***these dams are extremely dangerous.***

Lowhead Dam Dangers

There are hazards both in going over a lowhead dam and in the backwash below the dam. Anything caught in the backwash circulates round and round making escape or rescue difficult (see fig. 12-11). A dam does not have to be high to create a backwash. During periods of high water, the backwash gets worse and reaches farther downstream.

A person caught in the backwash first meets tires and logs on the water's surface and rocks and steel bars on the bottom. If you escape these hazards, the backwash will pull you under and recirculate you back to the dam where

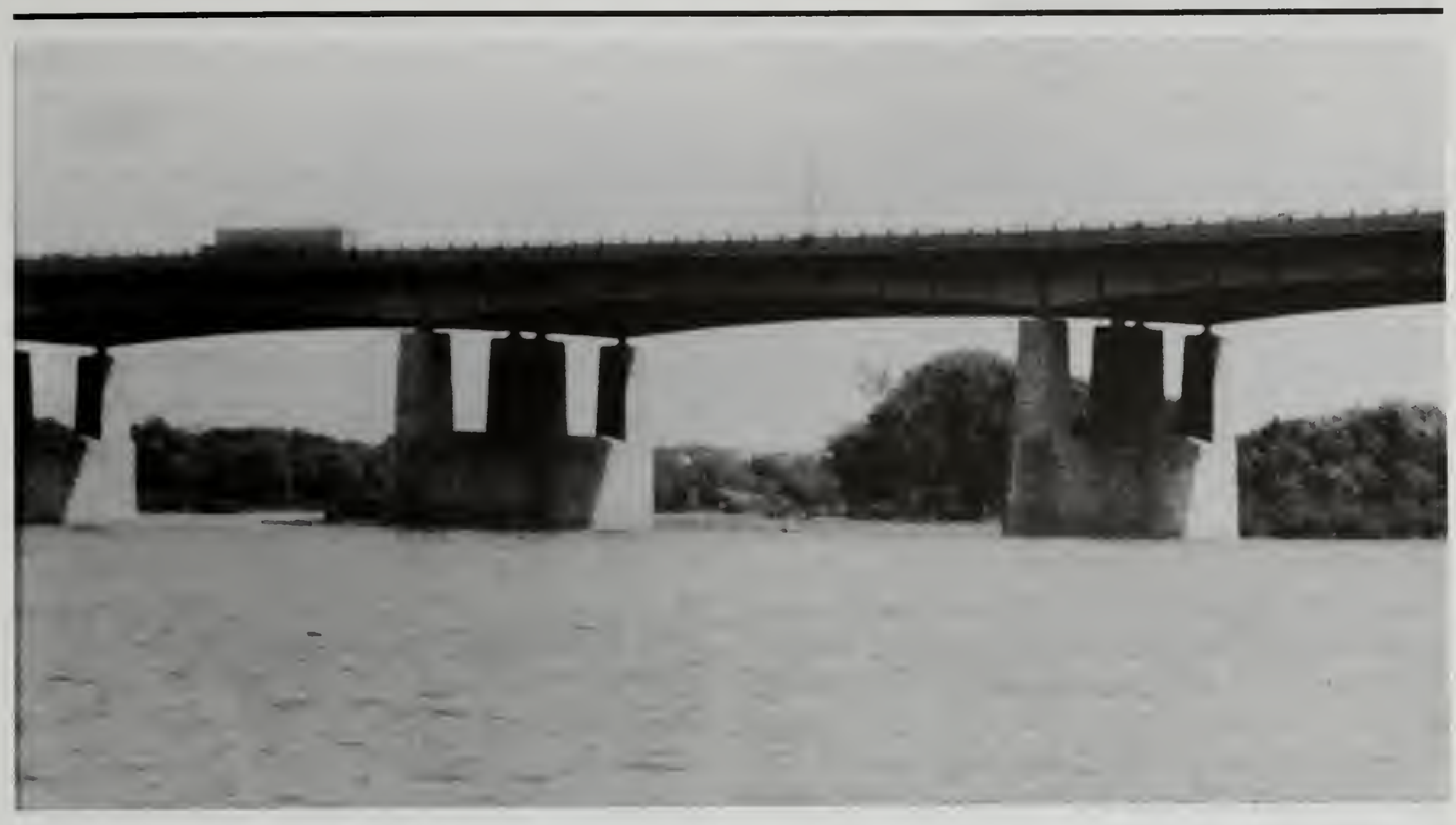


Fig. 12-9. From Upstream a Lowhead Dam is Hard to See.
(Photo by Virgil Chambers, Pennsylvania Fish and Boat Commission)

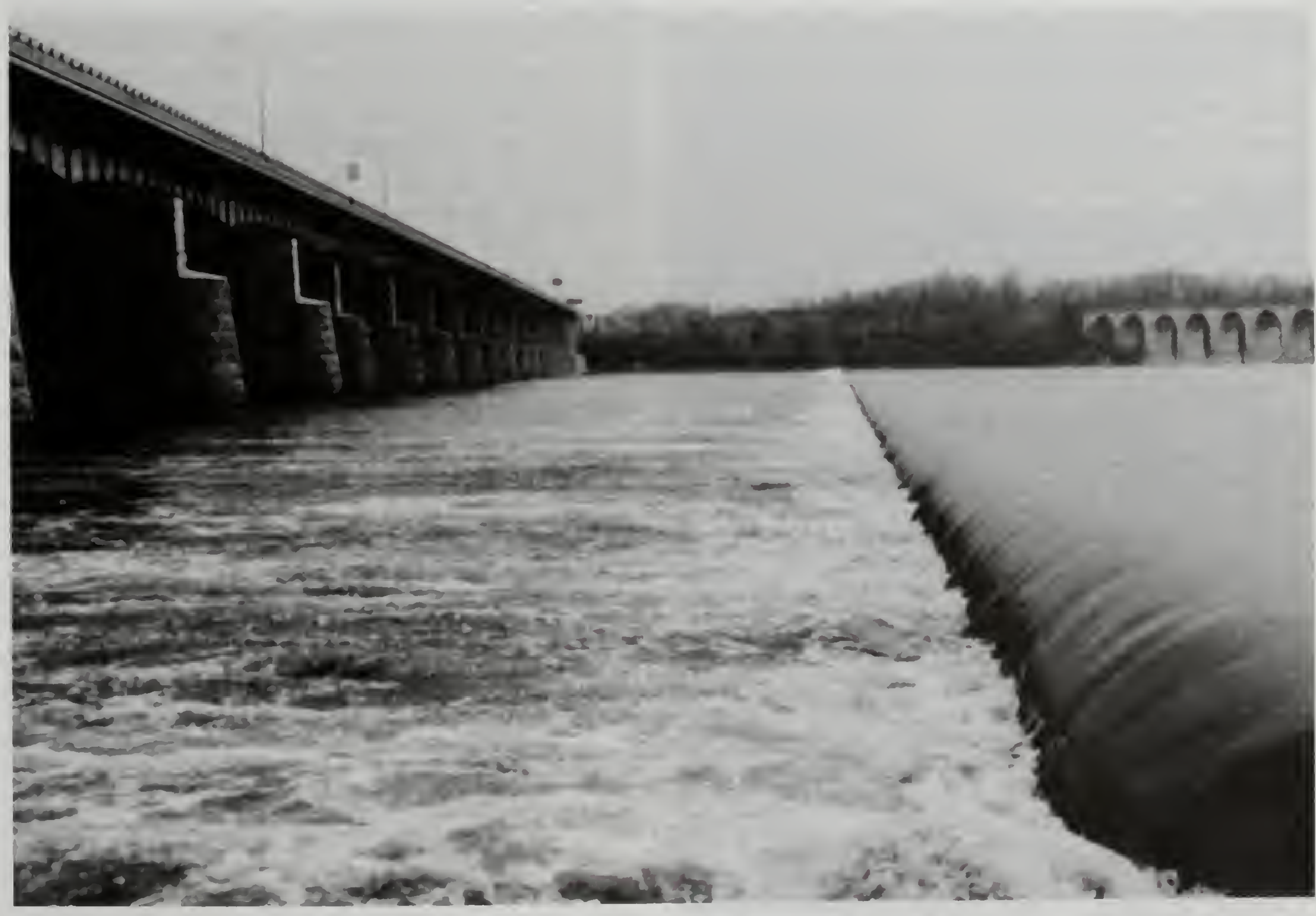


Fig. 12-10. The Same Lowhead Dam from an Across-the-River View.
(Photo by Virgil Chambers, Pennsylvania Fish and Boat Commission)

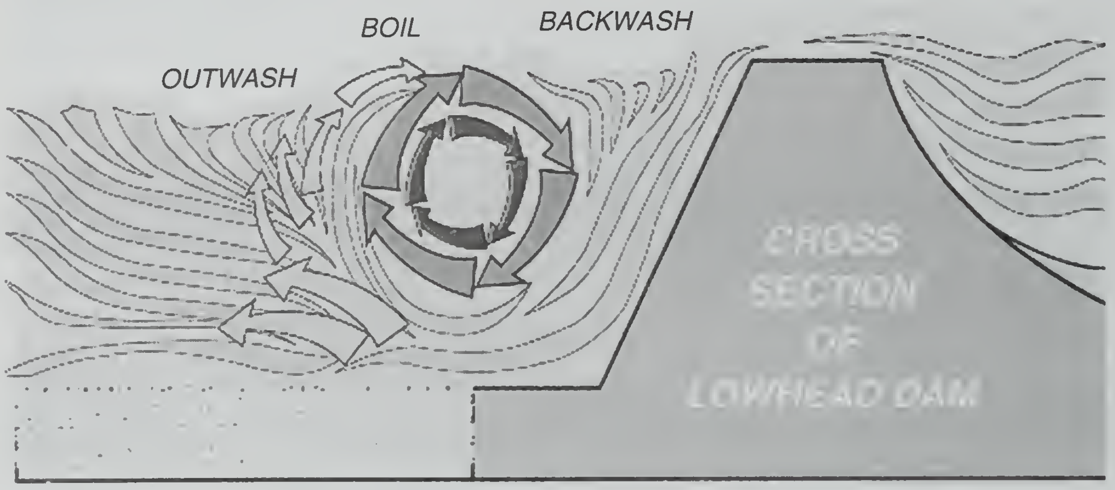


Fig. 12-11. The Hydraulic Backwash Below a Lowhead Dam

it will again catch you. You can escape by swimming underwater as far downstream as possible with the hope of coming up beyond the boil.

Another way of escaping is to swim laterally across the stream as you emerge from each cycle. This requires exceptional breathing control and endurance. Your chances of survival are greater if you are wearing a life jacket.

High Dams

Conventional dams with their large structures present more easily recognized dangers than do lowhead dams. Furthermore, there is usually a greater effort to warn unwary boaters of the presence and dangers of the dams. Most high dams have "keep out" buoys above them and "danger dam" buoys below them.

Restricted Areas

Areas immediately upstream and downstream of high dams are restricted and are marked by signs and buoys and, perhaps, by flashing red lights installed in conspicuous places. On the upstream side of many high dams, there are strong undertows. These result from the rush of water through open gate sections below the water's surface. If a boat approaches the upper side of a high dam too closely, the undertow may pin it against the dam or capsize it.

Dams have gates to allow the release of

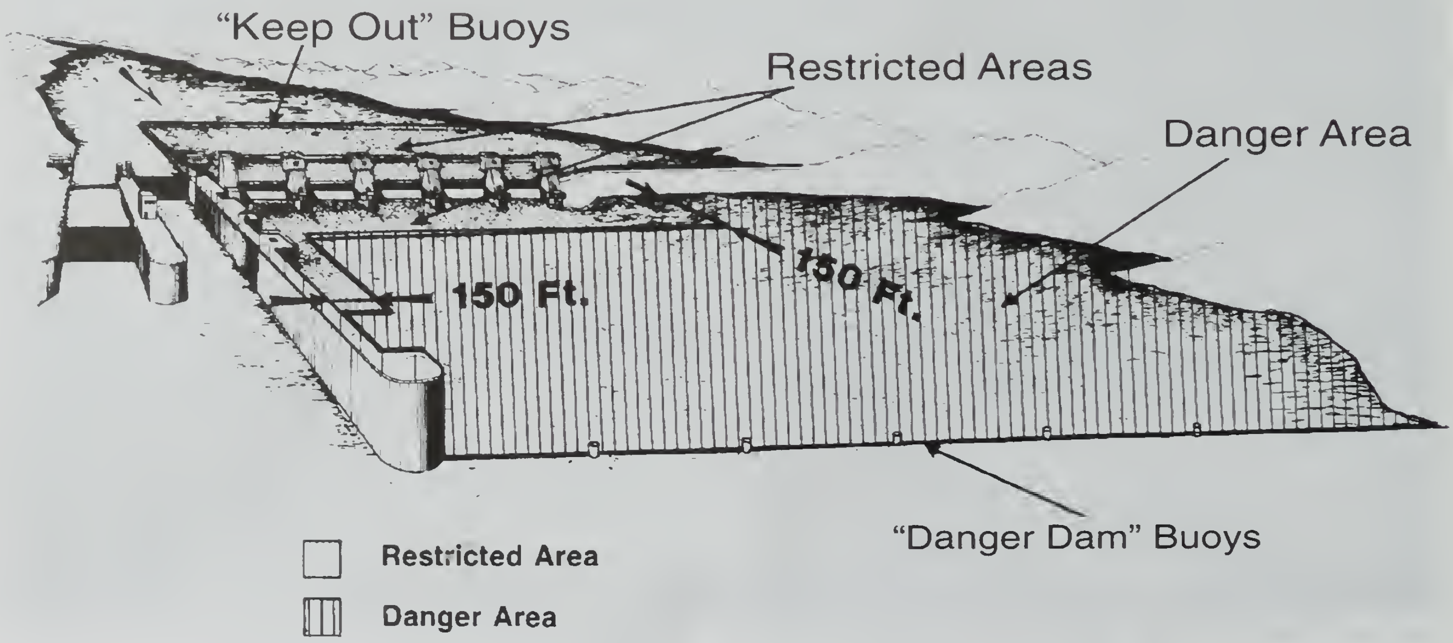


Fig. 12-12. Dams Are *Dangerous*. Stay Out of Restricted Areas.

water to the downstream pool. These gates open to control the flow of water during flooding periods or to generate electricity. Most dam operators sound horns or sirens before the gates open. If you hear them, get out of the way quickly.

Dam Gates

There are several types of dam gates in use. Wicket gates lower to lie along the bottom of the waterway. Water can pass above them. Their principal advantage is that in times of high water river traffic can pass over the dam. The height of the dam controls the type of wickets used.

From a recreational boater's point of view, wicket dams present potential hazards. Small boats can be swept over a partially open wicket.

More often, high dams use tainter gates. These allow water to flow downstream from the bottom of the dam. The advantage of the flow from the bottom is that it flushes sediment downstream. Since the openings are at the base of the dam, boaters cannot tell by looking if the dam gates are open. Open gates mean turbulent water, and this means a dangerous situation for small boats. A small boat caught up against the wall of a tainter dam may be held there until rescued, if it does not capsize or swamp beforehand. But don't count on being rescued.

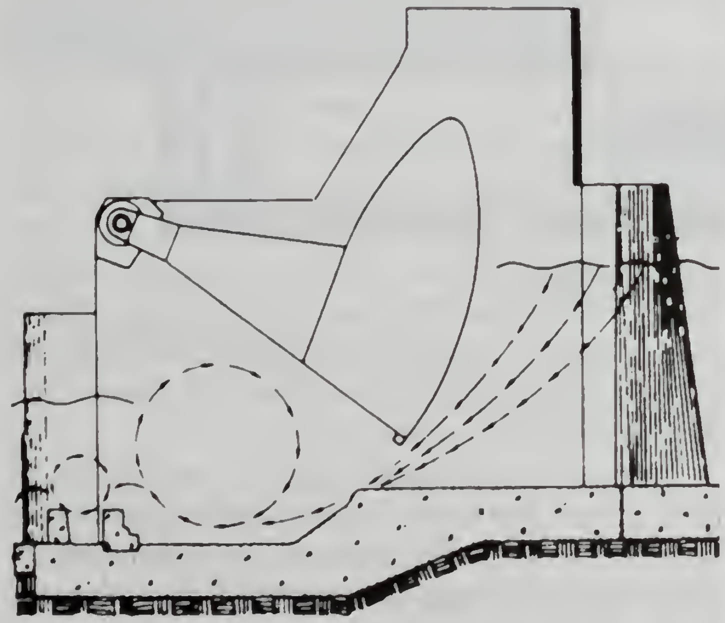


Fig. 12-13. A Tainter Gate

Fishing Below Dams

The **TAILRACE** or white water below a dam (fig. 12-14) is an enticing place in which to fish because the fishing is often good. The moving water churns up food on which fish feed. Don't succumb to the temptation. ***You may lose your boat and your life.***

Many accidents occur when small vessels enter restricted areas, especially those below high dams. If a hydroelectric turbine is turned on, it can send a wall of water six feet high that can swamp a boat tied to a short anchor line.

As with a lowhead dam, the water coming from a high dam creates a boil and a backwash. The only difference is that the boil and backwash of a high dam are many times stronger. At the water's surface, a strong current moves toward the dam. If you get into this current and have an engine failure, the current will push you to the face of the dam and swamp your boat. Getting out of the boil below a lowhead dam is difficult. Getting out of the boil below a high dam is probably impossible.

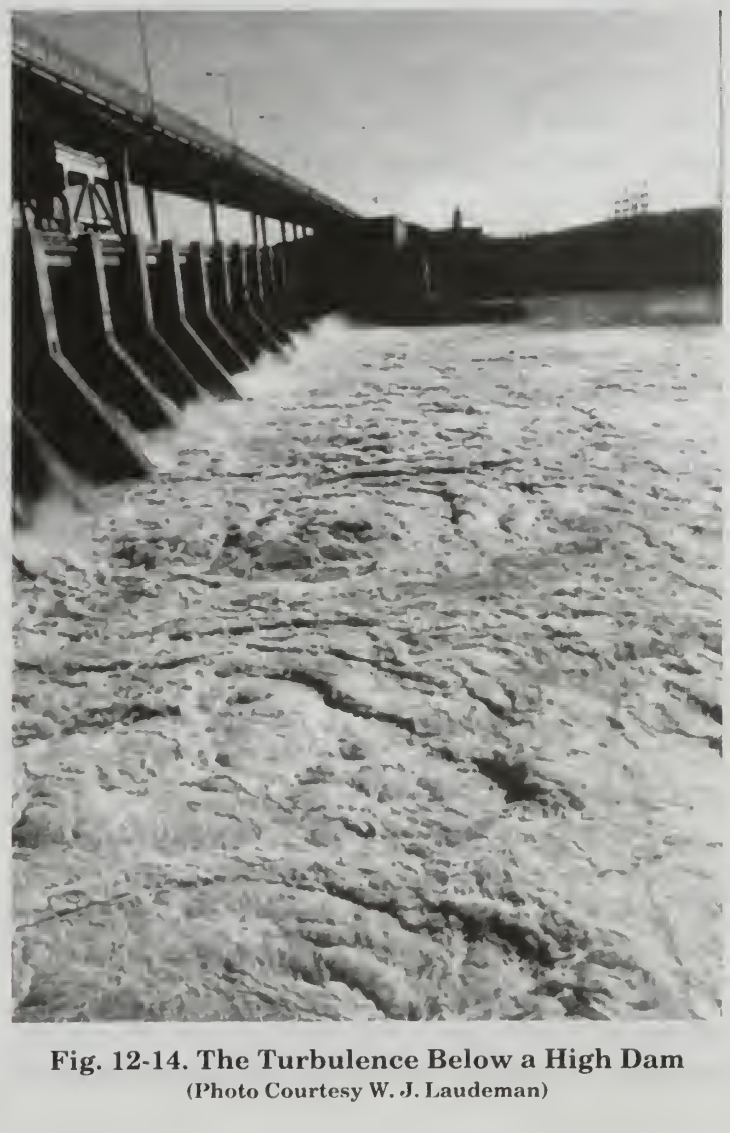


Fig. 12-14. The Turbulence Below a High Dam
(Photo Courtesy W. J. Laudeman)

Even if you don't experience engine failure, you may have a problem in the tailrace below a dam. From time to time, dams open for power generation or to lower the water level in the pools behind them. Sirens or horns sound before this happens but your engine may not start. You may be stuck and swamped when the dam opens. You may raise your anchor and hope to be carried downstream. Instead, if you are close enough to the dam, the current may push you to the dam's face.

If you are foolhardy enough to enter a tailrace, even below the counter current, be careful how you anchor. If you toss your anchor into the water instead of lowering it gradually, the current may catch the line and pull it under your boat where it can foul in your motor. This will stall your motor and you may begin to drift downstream. Sooner or later your anchor will catch on the bottom and your boat's stern will turn toward the tailrace. Very likely the current will swamp your boat.

LOCKS

Dams built on navigable streams must have some means of passing vessel traffic through them. Locks serve this purpose. They raise or lower vessels to the level of the next pool of water. A lock on a navigable river is a large chamber, most often about 800 to 1200 feet long and 100 to 120 feet wide. It has gates at each end. Locks on canals are often smaller.

Lock Operation

A vessel headed upstream enters the lock chamber through the downstream gates which close behind it. Valves in the lock then open to permit water from the upstream pool to enter the chamber. As the water level rises, the vessel rises with it. When the water level in the lock is even with the level of the upstream pool, the flow of water stops. The upstream gates open, and the vessel moves out of the chamber and continues on its way.

A vessel headed downstream enters the full chamber and the gates close behind it as in figure 12-15. The water from the chamber then drains into the lower pool. This lowers the vessel to the level of the lower pool. When the water inside the lock is at the same level as the water in the lower pool, the lower gates open and the vessel moves on.

Gravity powers the entire operation of lifting or lowering a vessel in a lock. Electrical power, however, opens and closes most gates. In some small locks, the gates open and close manually.

The Lockmaster

The building, maintenance, and operation of river locks are the responsibility of the Corps of Engineers. Each lock is under the control of a lockmaster who is entirely responsible for its operation. Whenever possible, a lockmaster will lock you through immediately, but there may be more pressing needs. These may cause you to have to wait. Rest assured that the lock–master will lock you through as soon as possible.

Priorities for Use

Federal regulations establish priorities for vessels using locks. Military vessels and mail packets have the highest priority. Commercial vessels have the next highest. Recreational vessels have the lowest priority.

This is not as bad as it may sound. There are only a few naval and military vessels on the waterways. Mail packets are rare, and passenger-carrying vessels are not common. Usually, the "competition" for lockage is commercial barge traffic.

Coexisting with Commercial Traffic

On occasion, it is possible to lock through with barges. This depends upon the available space in the lock, the nature of the cargo, and the wishes of the towboat operator. The first responsibility of the towboat operator is the safety of the tow. If you lock through with a tow, quarters may be tight and you may be moving close to the tow or the lock gates. You need to exercise extra caution.

At times a string of barges is too large to fit into a lock chamber. When this happens, the operator breaks the tow into two or more parts and locks through in sections. Recreational boats sometimes can lock through in the opposite direction as the chamber is being filled or drained. When this happens, move quickly. The tow operator's time is valuable.

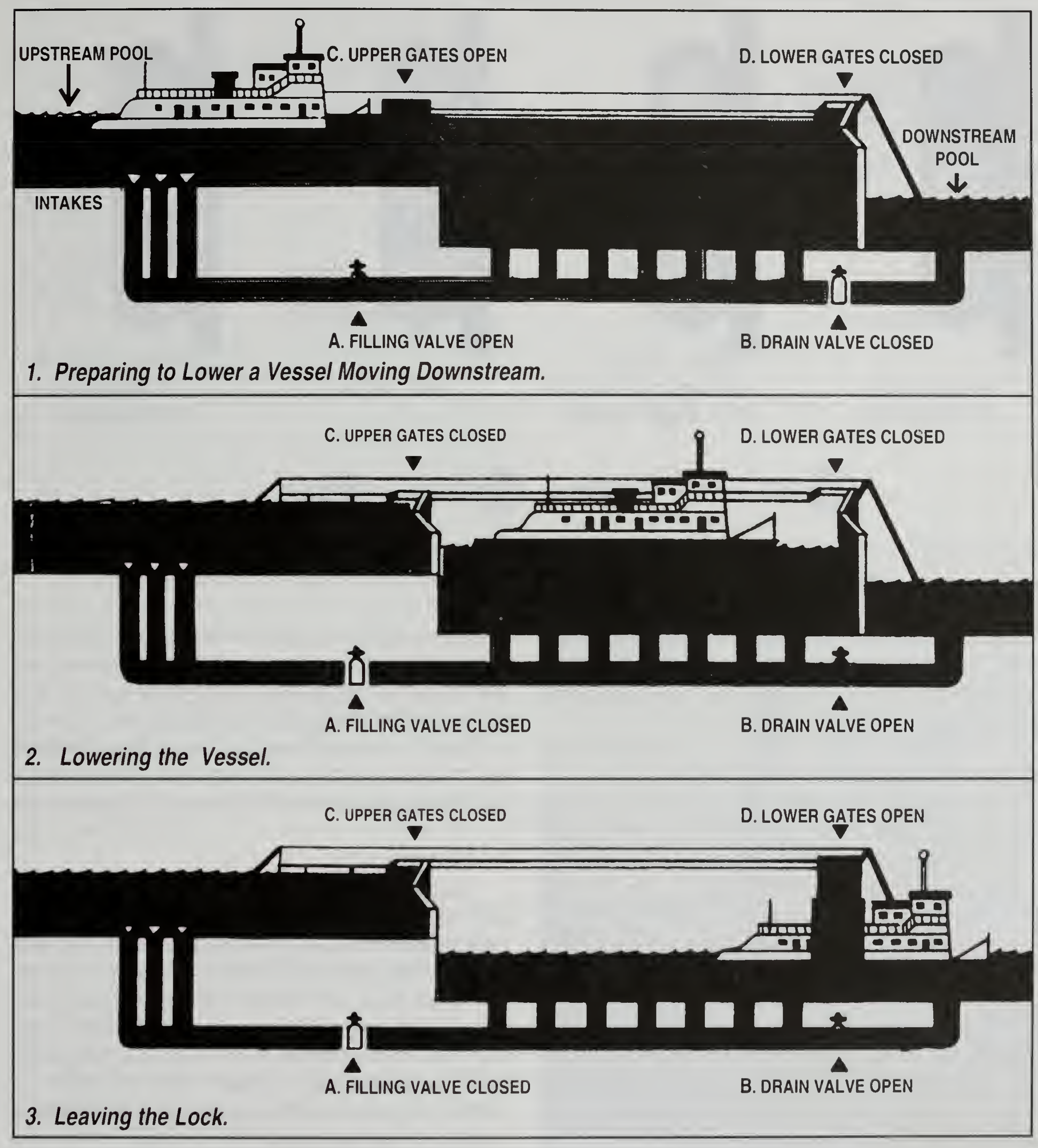


Fig. 12-15. Operations of a Lock

Hazardous Cargo

Regardless of how much space is available, other vessels do not lock through with hazardous cargoes such as gasoline or sulfuric acid. Vessels with hazardous cargoes fly the international code flag BRAVO. This is a red, swallow-tailed pennant, usually made of sheet metal so it is always visible. Be especially careful near such cargoes. Their river transport is safe, but any accident that does occur has the potential of being a major disaster.

Plan on some delay at locks. If commercial traffic is heavy and several tows are waiting at a lock, the delay can be several hours. Be pa-

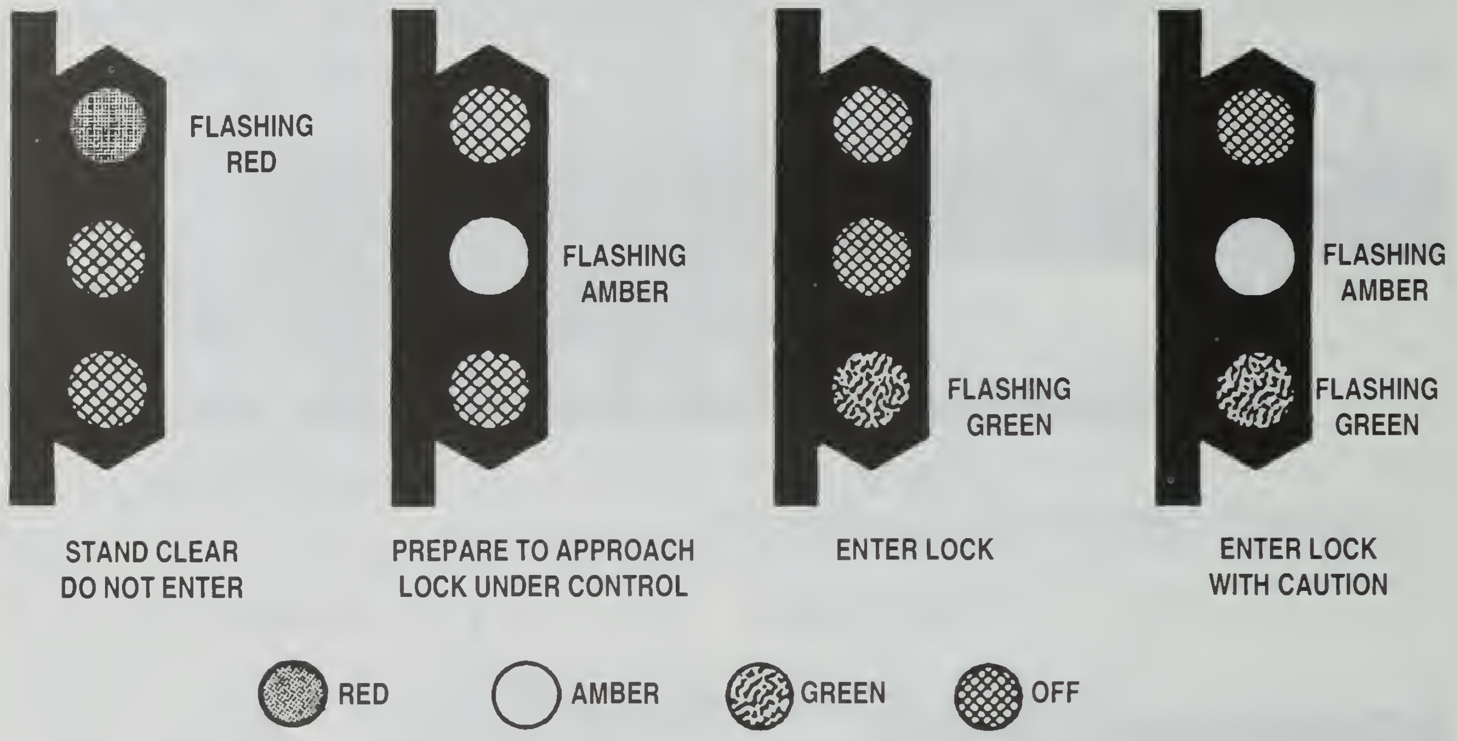


Fig. 12-16. Light Signals at Locks

tient but also rest assured that the lockmaster will take you as soon as possible. Few lockmasters want recreational boats loitering near their locks.

Communicating with the Lockmaster

You can reach the lockmaster on channel 16 of your VHF-FM radio. You will probably be asked to switch to Channel 13. Contacting the lockmaster in advance by radio can be helpful for both you and the lockmaster. When lockmasters know what traffic to expect, they can plan their moves and make more efficient use of their facilities. If you know what is going on, you can adjust your speed and plans accordingly. You can possibly speed up and get into a group locking through or you may take a lunch break while a barge or a restricted tow locks through.

You should understand that if you are locking through with a tow or several recreational boats, the lockmaster may not be able to respond immediately to your radio call. Make it a practice to listen to radio traffic then you will know what is going on and may not have to call the lockmaster.

Corps of Engineers operated locks are equipped with a manual, "Small Craft Signal." This is usually a chain or pull-rope and is located at the outermost end of the lock wall. It will have an explanatory sign. If you do not have a VHF-FM radio, use this signal. Give it *one* pull. You may not be able to hear it from your location so stay where you are and await the lockmaster who will give you instructions.

Traffic Signals

Light or whistle signals may advise you how to proceed in entering or leaving a lock. Light signals typically resemble traffic signals (see fig. 12-16). You respond to them in much the same way. A red light means "do not approach." A yellow light, often flashing, says that you should prepare to move into the lock. Don't start toward the lock while the light is yellow. A green light signals that the lock is ready to receive vessels.

Sound signals are of two types (fig. 12-17). One prolonged blast (four to six seconds) means enter the lock. One short blast (one second) means leave the lock.

Be careful when you see or hear the signals. They may not apply to you. If there are other vessels waiting for lockage, the signal may be for them. They may have a higher priority than you do.

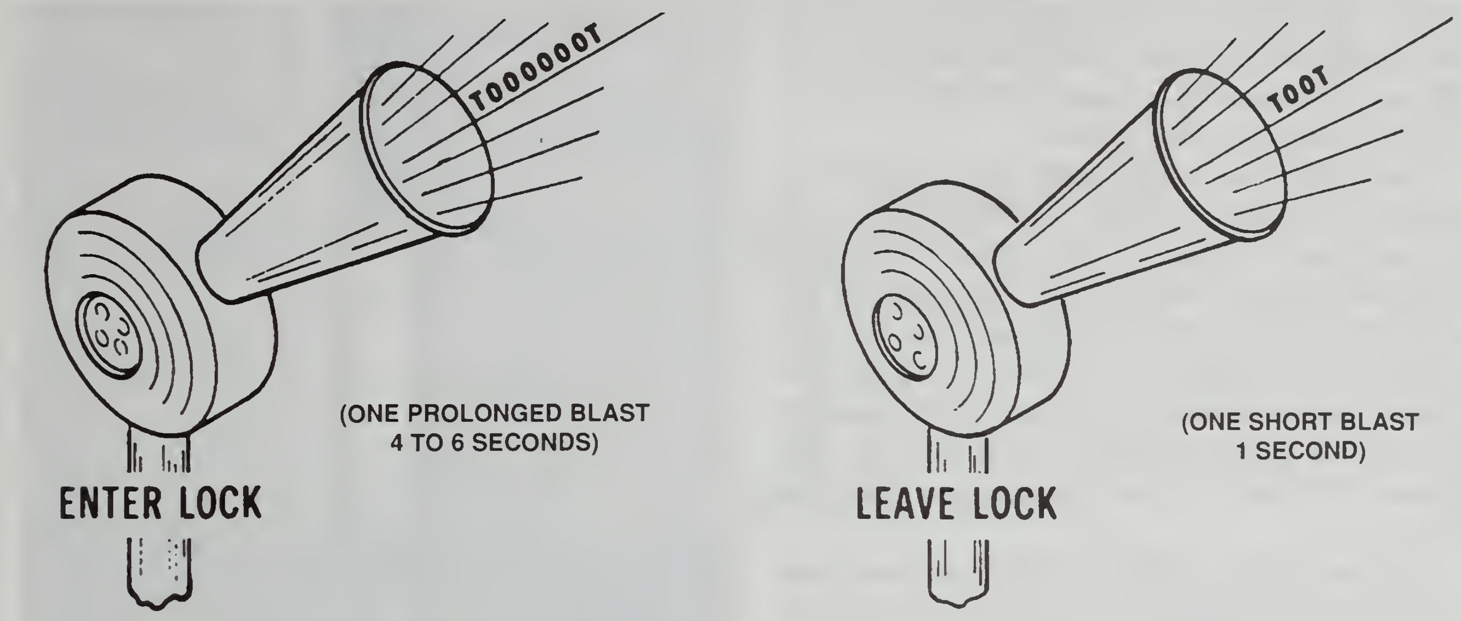


Fig. 12-17. Whistle Signals at Locks

Locking Through

As you approach the lock chamber, move without a wake. This usually means a fast idle speed. There is a conflict between the need to move quickly and the need to keep your wake down. Avoiding wakes takes priority. A lock is a long, narrow chamber with flat concrete walls. The wakes of boats bounce off these walls. When several boats are moving near each other, be extra careful to avoid damaging boats or lock gate mechanisms.

Conduct in the Lock.

All crew members must wear life jackets during the locking operation. The lock chamber can be turbulent when filling or emptying. You and your crew members will be moving around, tending lines. It is a dangerous time to fall overboard.

As a precaution against fire, you must stop your engine and extinguish all flames. *Smoking is not allowed.* With several boats in close quarters in a closed chamber, a fire could be a disaster.

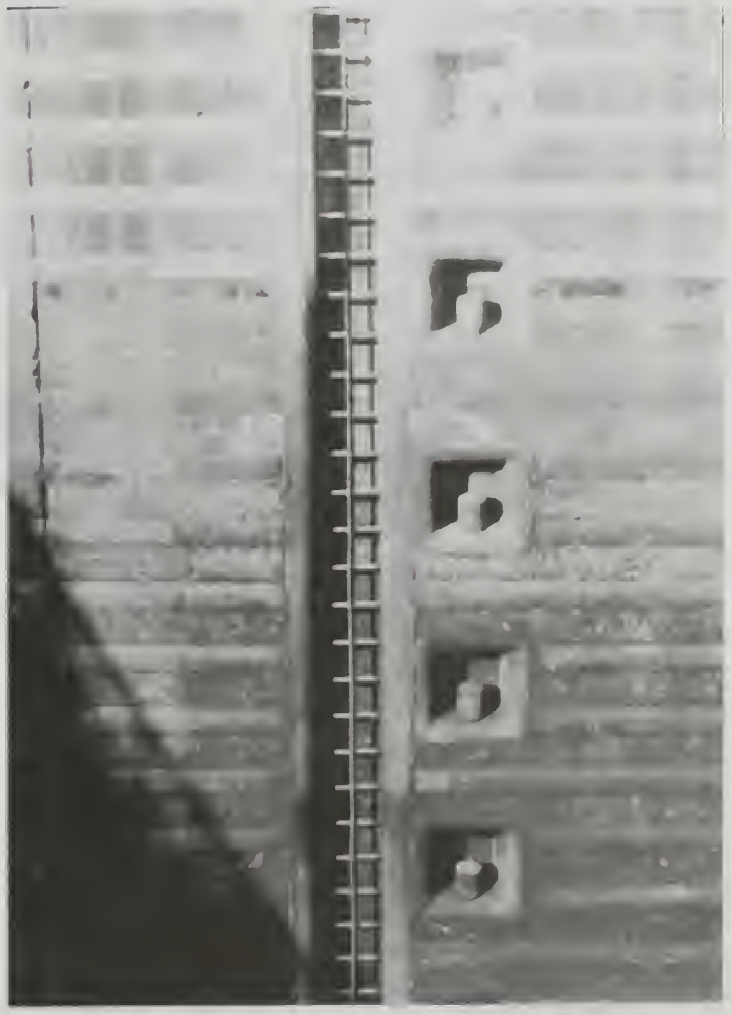


Fig. 12-18. A Ladder and Fixed Bitts in a Lock Wall
(Photo Courtesy of W.J. Laudeman)

Tying Up in the Lock.

Prepare to tie up to bitts or bollards in the lock using your own lines. Since the walls of locks are often rough and dirty and may have sharp, exposed metal pieces, you will want to make liberal use of fenders. Use boathooks or poles, rather than hands and feet, to keep your boat away from the lock wall. Small boats usually use only one line. Boats larger than 25 to 30 feet need lines fore and aft.

Lock bollards are of two types, fixed and floating. Fixed bollards are usually at the top of the lock wall. They require lines more than twice the depth of the lock. On a small boat you tie one end of a line to a bow cleat, loop the line around the bollard, and tend the other end around a stern cleat. If you are being lowered, you let out line from the stern cleat as you progress. If you are being raised, you take up line.

In other locks, there is a series of fixed bitts in the lock wall (fig 12-17). Ladders sometimes serve the same purpose. In such locks, you must move your line from attachment point to attachment point as you are raised or lowered.

Some larger locks have floating bollards (figs. 12-19 and 12-20). If so, secure your line to a bow cleat, take a turn around the bollard, and tend the other end of the line at a stern cleat. With this type of bollard, you neither have to take up nor pay out line. You must tend the line carefully, though, and take action in the unlikely event that the bollard jams and does not move up or down. In that event you may need your long line.

Floating bollards may jam from debris snagged in them. If one jams, you must take your line from it and fasten it to a ladder or to a fixed bitt in the wall. When you retrieve your line from a jammed bollard, be careful. The bollard may free itself and float to the surface with considerable force.

I THINK YOU'RE HOLDING THE LINE TOO TIGHT, HONEY

First Time Through the Locks

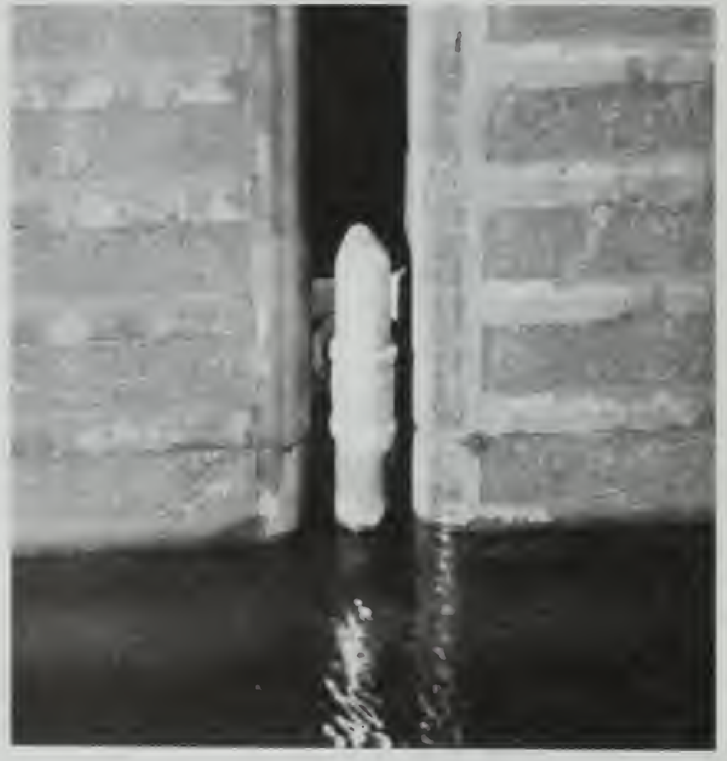


Fig. 12-19. A Floating Bollard in a Lock Wall
(Photo Courtesy of W.J. Laudeman)

Rafting Up

When many small boats lock through together, there may not be enough space along the wall to accommodate all of them. Break out your fenders and lines and raft up with the other boats if requested (fig. 12-21). The lockmaster will tell you where to go on the wall, and may tell you which boats are to raft with you.

Leaving the Lock

After the water in the lock has reached its desired level, wait for the lockmaster's signal before moving out. Again, move at a no-wake speed, paying close attention to the other boats that are getting underway at the same time.

Please note that the signals and procedures outlined here are general guidelines. Significant variation exists in regulations from waterway to waterway and in the design of locks. You should familiarize yourself with local conditions and procedures before using the installations whenever possible.

RIVER CHARTS

The Corps makes most of the charts used for river piloting. These charts differ in many respects from those used in coastal piloting. They are often published as spiral bound books. Each page contains a chart of a section of the

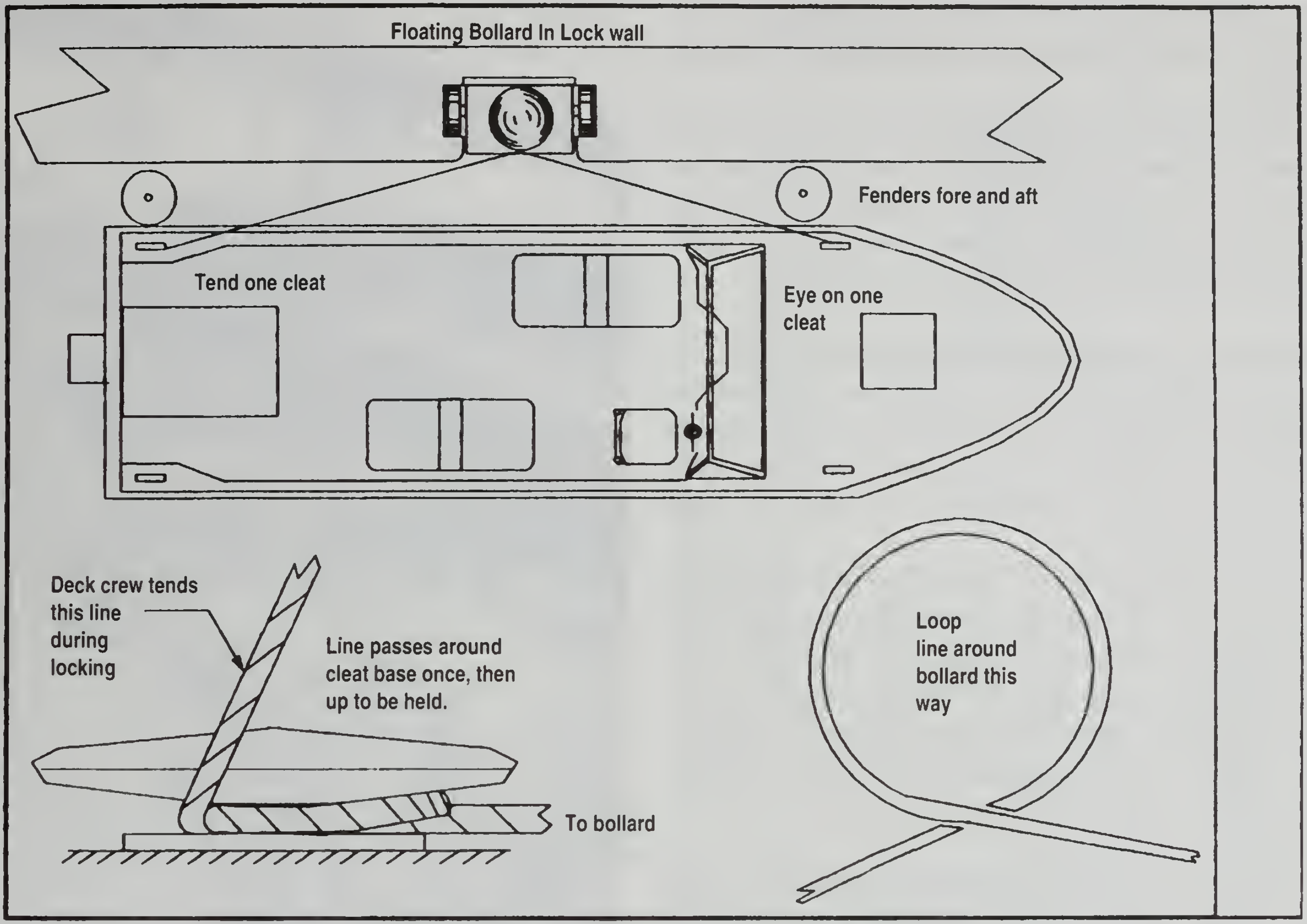

Floating Bollard In Lock wall
Fenders fore and aft
Tend one cleat
Eye on one cleat
Deck crew tends this line during locking
Line passes around cleat base once, then up to be held.
To bollard
Loop line around bollard this way

Fig. 12-20. Tying Up To a Floating Bollard.
(Drawing by W.J. Laudeman)

river. Because of this, river charts can have large scales and still be handled conveniently aboard recreational boats.

Characteristics of River Charts

River charts appear in a variety of formats. Many are little more than simple sketches that show the principal geographic features of the waterway, the channel and its SAILING LINE, prominent structures, and fixed aids to navigation. Others, such as the chart of the Warrior River in Alabama are aerial photographs on which symbols have been printed. Some charts, including those of the Mississippi, show the positions of navigation lights but do not show the lights' characteristics. An up-to-date copy of the *Light List* (see chapter 5) will help you know which light you are viewing.

Depths of water seldom appear on river charts. Since river depths vary greatly from time to time, they would be meaningless. When a chart shows floating aids to navigation, consider their positions approximate and use them with caution. The Coast Guard moves them frequently. It also sets additional buoys during periods of low water to mark shoals that are not of concern when the water is higher.

Unlike coastal charts, landmarks such as smokestacks, water towers, and antennas do not usually appear on river charts. Often, only those structures close to the banks are shown and then only by symbols and footnotes. Many of these symbols are unlike those on coastal charts. Look on the front pages of the chart book for the key to the chart's symbols. It is best to spend some time studying your chart before you begin your voyage.

On most river charts, information about bridges such as ownership, types of bridge, vertical and horizontal clearances, and locations can be found in the information block (the "legend"). The horizontal clearances of swing and draw bridges are given for both their open and closed states. Vertical clearances are given for some bridges at pool stage. For others, vertical clearances are given for "normal high water." Locations are given by mile markers. Most bridge tenders can be reached on VHF-FM channel 16.

Some river charts do not show geographical names for areas along their banks. Likewise, most do not include roads other than those which cross the river. A good road map may be a useful supplement to your river chart.

A Chart of a Section of the Missouri River

At first glance river charts may appear inadequate to boaters accustomed to using coastal charts. Careful study will show you that they have most of the features you need to boat safely on the river.

The chart in figure 12-22 shows a section of the Missouri River. With the page turned sideways, the river flows from left to right. You can tell this from the arrows on the river in the upper left and right corners. North is to the left and south is to the right. You can tell this by the arrow with an "N" on it near the upper right side of the page.

As shown on the lower right of figure 12-22, it is Chart No. 27. Chart No. 26 joins it on the left and Chart No. 28 on the right. The match lines for the charts appear as dotted lines. The overlap of the pages makes it easier to pass from page to page.

Revetments appear as crosshatched areas. As you would expect, these appear at bends in the river. Dikes and wing dams jut out from the banks and appear as solid and dotted lines.

Mileages are printed on the "sailing line" that marks the channel. Mileage markers appear at easily seen points such as the daybeacons at Sarpy, Bellevue Reach Upper, and Bellevue Reach. Since the Corps measures the Missouri from its mouth to its source, the mileages decrease as you go down the river.

Daybeacons

As already discussed, daybeacons offer invaluable guidance to riverboaters, especially large commercial craft. They are printed on the chart in the order you see them as you move either up or down the river. (On figure 12-22, the red daybeacons appear in black while the green daybeacons are dotted and gray. On the charts, they are red or green.)

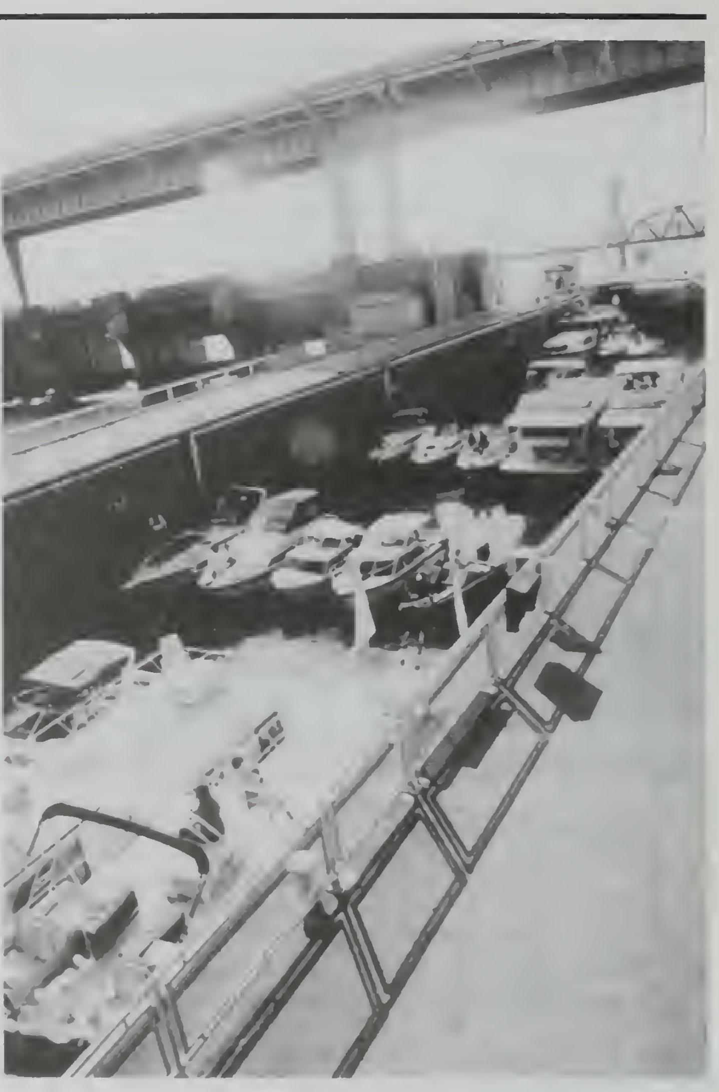


Fig. 12-21. Rafting Up in a Lock
(Photo Courtesy W.J. Laudeman)

For example, when you pass Manawa at mile 604.6 going downstream, you see a red triangular, passing daymark on the left descending bank. On the back of the triangle is a red diamond crossing daymark. If you look back upriver as you pass these daymarks, you see the red diamond and know that the next daymark will be a green diamond on the opposite bank. When you look downriver, you see the green diamond passing daymark at Sarpy and head for it (also see fig. 12-23).

Since the diamond at Sarpy has a green square on its back side, you know that the channel continues along the right descending bank. It continues there until Bellevue at mile 601.3. At that point you learn that the channel crosses over to the opposite bank and you head to the markers at Treynor. You can tell the course of the channel by observing the sailing line.

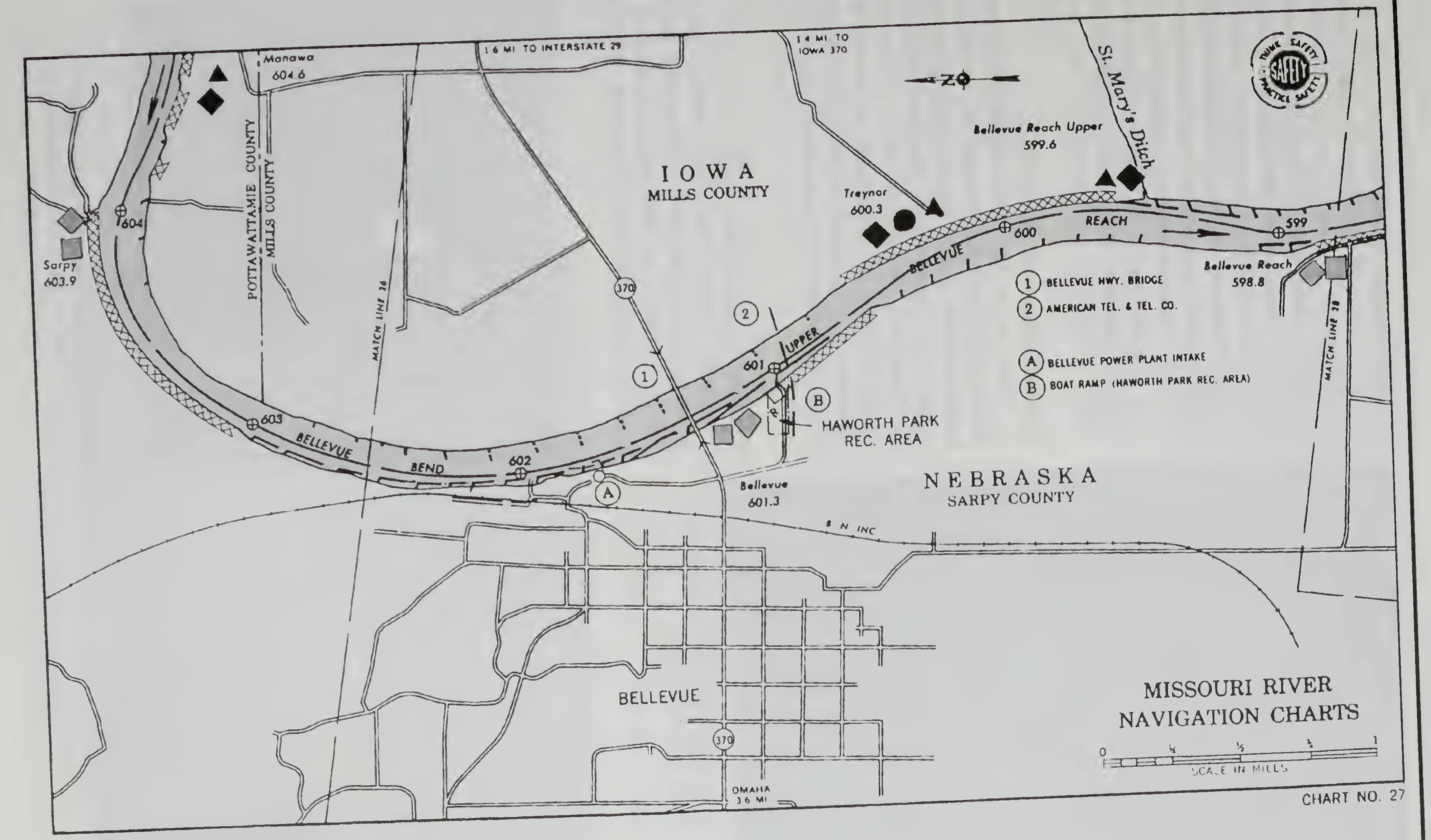


Fig. 12-22. A Portion of a Missouri River Chart

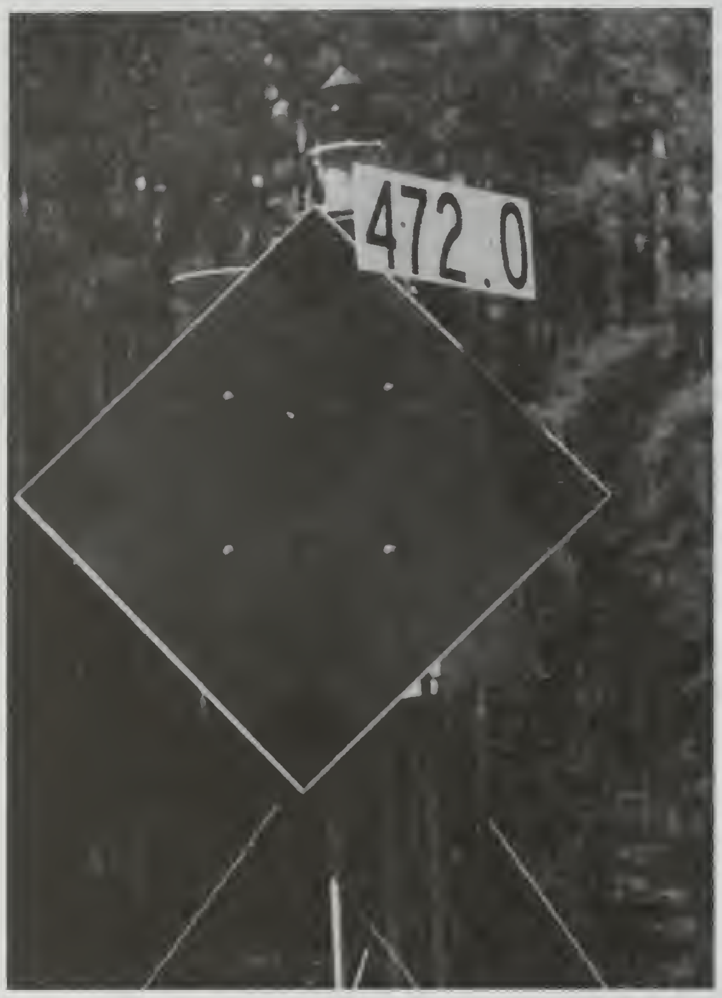


Fig. 12-23. A Crossing Daymark with a Light and a Mile Marker

Navigation Lights

The locations of navigation lights are also shown on some river charts. In figure 12-22, the black disk between the red triangle and the red diamond at Treynor (mile 600.3) appears as a red disk on the chart. It stands for a red navigation light. Some disks are green to correspond to the green lights they represent. As you would expect, red lights mark the left descending bank and green ones mark the right descending bank.

In some cases, the disks have the letter "P" overprinted on them. This means a privately maintained light. If it does not have the "P," the U. S. Coast Guard maintains it. River charts do not show the characteristics of navigation lights such as their colors and periods. You can tell their characteristics by referring to the *Light List*.

COMMERCIAL TRAFFIC

A variety of commercial traffic uses the Inland Rivers. In some places you can see ships, often from foreign ports. You also can see cruise ships and floating casinos. Most often, though, commercial traffic consists of tow boats with strings of barges. Usually, the barges are lashed alongside their tow boats or are pushed ahead of them. They are rigidly connected so that they can be maneuvered as a single unit. A string of barges such as this is a **COMPOSITE UNIT**.

Ocean-Going and River Tows

There is an important difference between ocean-going and river tows that recreational boaters should know about. Ocean-going tugs usually tow their loads well behind them. Long steel cables that dip just below the water's surface connect the tugs with their tows. This presents a dangerous situation for boaters. *Never cut between an ocean-going tug and its tow.*

You and a River Tow

It takes a long distance for tows to get up speed or to stop. As a result, they stop only to break out a barge, to pass through a dam, or to tie up to the bank because the water is too low

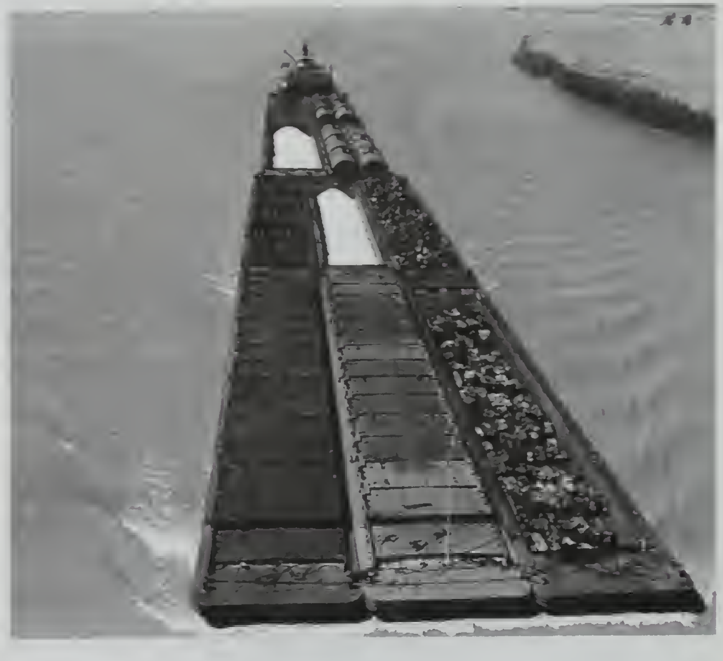


Fig. 12-24. Towboat on the River
(Photo Courtesy of Corps of Engineers)

or too high. Tenders deliver provisions and fuel to them while they are underway.

An average commercial river tow is about 1,150 feet long with a beam of 105 feet. It draws 8.5 feet and weighs 60,000,000 pounds. Its engines develop as much as 5,600 horsepower.

In contrast, the average pleasure boat is less than 20 feet long with a beam of less than eight feet. Its draft is two feet, and it weighs about 3,000 pounds.

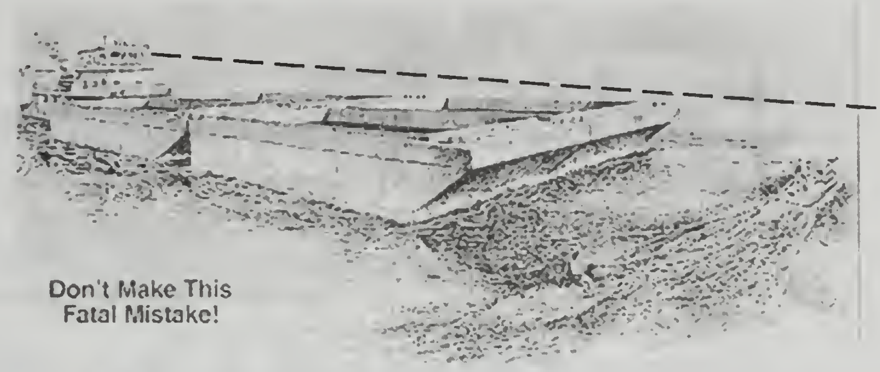


Fig. 12-25. View From Towboat Pilothouse

Watch Out for the Tow

Obviously, commercial tows are big and you are small. It's like comparing a Volkswagen "beetle" and a train. This means the tug and tow are big and you are small. The tug has .2 horsepower per ton while you have 133 horsepower per ton, and you can stop quickly. It may take up to a mile to stop a downbound tow when the river is running. The tow also requires a lot of room in which to maneuver.

With your shallow draft, you can go bank-to-bank almost anywhere. The tow is limited in where it can go. The tow cannot turn wherever it wishes due to its draft.

Some tugs have as many as three large propellers. Driven by a tug's large engines, they can produce a "prop wash" you can feel hundreds of feet behind them (fig. 12-26). The propellers also churn debris from the bottom that may be hazardous to small craft. It makes sense to give tows as wide a berth as possible.

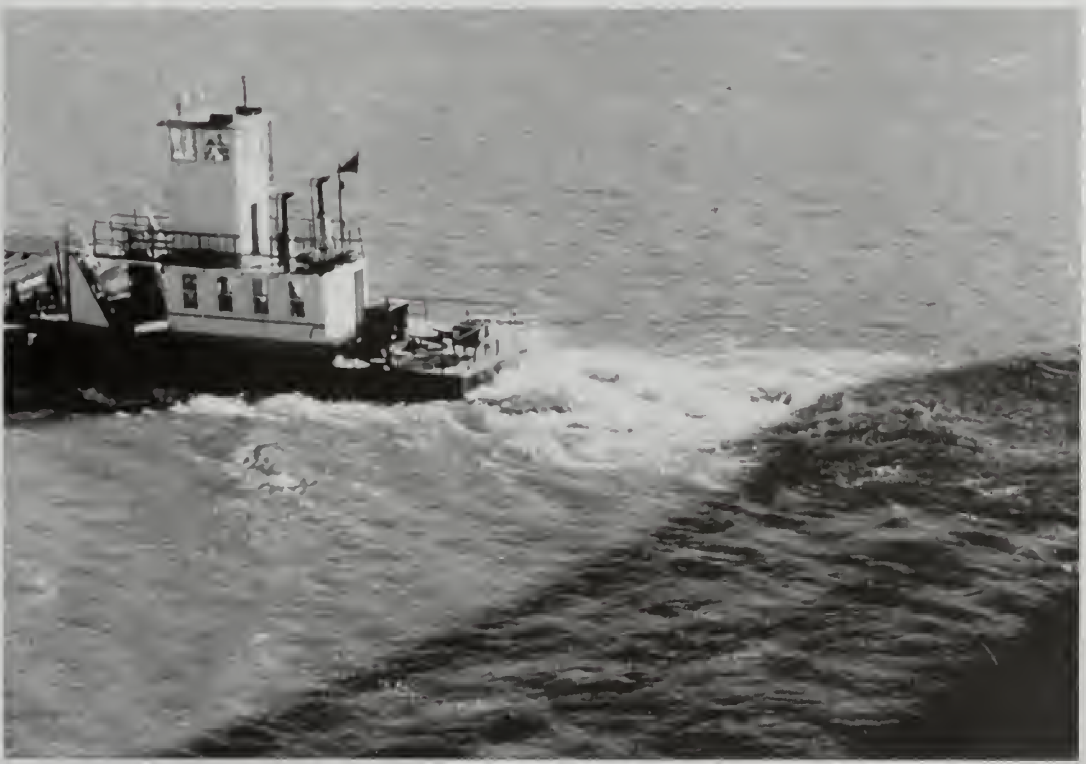


Fig. 12-26. The Turbulance Behind a Towboat
(Photo Courtesy W.J. Laudeman)

The Tow's Blind Spot

The operator of a tug pushing a string of barges is in the pilot house at the after end of the tow, as in figures 12-25 and 12-27. Although most towboats have high pilot houses, there is always an area immediately in front of the tow that is blocked from view. This blind zone typically extends 600 feet or more ahead of the tow.

When boating near a tow, be sensitive to the tugboat operator's field of view. Avoid running into the blind zone. It is tempting to move back to the center of a channel as soon as you pass a tow. This usually means that you are moving into the blind zone or towing a skier into it. If you have an engine failure, strike a submerged object, have someone overboard, or drop your skier, the towboat operator will never know even when the tug runs over you. Even if there is a lookout posted on the bow, the operator cannot stop the tow in time to avoid hitting a stalled boat or someone in the water.

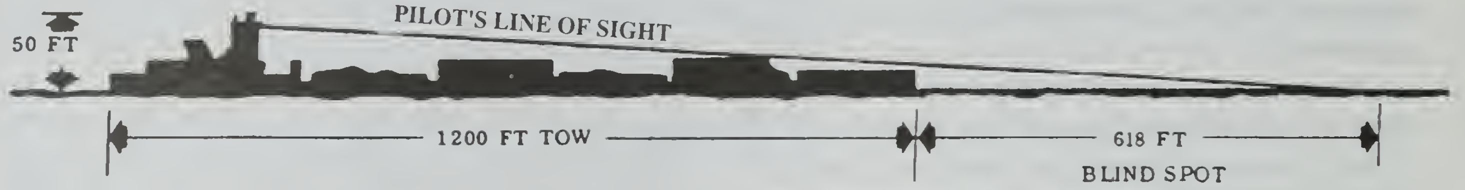


Fig. 12-27. The towboat captain's "blind spot" extends far ahead of his tow. If you can't see him, he can't see you!

Communicating with Commercial Traffic

When you meet or pass a tow, remember that the sound signals required by the Inland Navigation Rules are in effect. Use your sound signals to communicate with the tow and to respond to signals from the tow. These are the signals for meeting head-on, crossing, or overtaking.

It is very possible that the towboat operator will not hear your sound signals. There is a high noise level in the pilot house from the tug's engines and the pilot house is probably air conditioned. Because of this, the towboat operator will probably expect your contact to be by VHF-FM radio.

Call the tow operator on channel 16 and be ready to switch to channel 13 as a working channel. Vessels working around docks or barge staging areas where the radio traffic is heavy may direct you to a different working channel. When you talk to a towboat, be certain that it is the towboat you are near and not one farther up or down the river.

If you find yourself in a narrow channel with a tow approaching, move to the edge of the channel. If there is still not enough room for the tow to pass, move out of the channel if the water is deep enough. If not, turn around and retreat to a safe position below the narrow channel. For practical purposes, the responsibility for avoiding a collision is yours.

Avoid meeting tows in a river bend. If you are monitoring your VHF-FM radio, you should know where the traffic is. Wait for the tow to pass through the bend, if possible. If a tow catches you in a bend, move to the inside of the bend. The towboat will follow the channel. It is most likely on the outside of the bend.

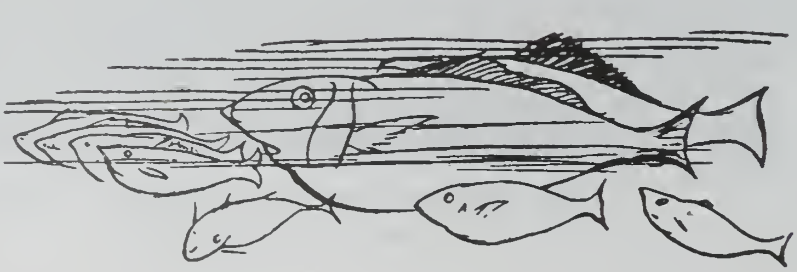
Obviously, a VHF-FM radio is essential equipment. You also should consider installing a radar reflector on your vessel since towboats have radar. In this way, you can help the towboat operator see you.

BEFORE YOU GO

Before you venture out onto a river, study its chart. This will alert you to hazards including dams and low drawbridges, and will help you gain a general orientation to the river. Being informed is better than being surprised.

If you are moving your boat from another body of fresh water to this river, remember and observe the precautions regarding zebra mussels outlined in chapter 3.

Drawbridge signals and regulations were discussed in chapter 6, "The Rules You Must Follow." You should review that discussion before you boat on a river. Although most highway and railroad bridges are high enough to permit the passage of most recreational craft beneath them, you may meet one that is not high enough. This is more likely to be the case if your vessel is a sailboat than if it is a motorboat.



13

The Rest of Our Story

There are additional problems and skills we need to discuss. Some of these apply to small boats. Others apply to all boats. They include problems of small boat safety, personal watercraft, hypothermia, motorboats near sailboats, and carbon monoxide gas.

SMALL BOAT SAFETY

Most boats in use today are less than 16 feet long. Over 90 percent are less than 20 feet long. Most are stable and safe when used properly. They are subject to misuse, however. More than one-half of all boating fatalities occur in boats 12 to 16 feet long.

Boating Fatalities

Contrary to popular opinion, about one-half of all boating fatalities occur in lakes, ponds, and reservoirs and not on navigable waterways. Over one-half of the fatalities occur on weekend afternoons. About one-half occur in calm weather and in full daylight.

Of those involved in fatal boating accidents, about two-thirds have had no training in boat handling and safety. Actually, many of them probably do not even think of themselves as boaters since about 25 percent fish, and some hunt. They stand up to shoot, to land fish, to start their engines, to raise their anchors, or for other reasons. Their boats capsize or swamp or they fall overboard. They are not only young people; almost one-half are 26 to 50 years old.

They have one thing in common with many motorists who do not buckle-up; 87 percent do not wear life jackets. A large percentage has been drinking.

Causes of Boating Fatalities

Most fatal boating accidents involve people who suddenly and unexpectedly find themselves in the water without life jackets. Their boats capsize, they fall overboard, they collide with other boats or objects, or their boats swamp. Being able to swim is not sufficient protection if you find yourself in the water unexpectedly. Nearly 90 percent of people who lose their lives in boating accidents drown even though most of them are “swimmers.”

Sadly, most fatal boating accidents involve people who have life jackets on board their boats but who are not wearing them. A life jacket aboard will not help you if you fall overboard without it and your boat floats away from you or if you can’t reboard the boat. If your boat capsizes and your life jackets are in a cabin, you probably cannot get to them. Small boats that capsize often trap life jackets under their thwarts or seats.

Small boats are safe. The problem is that their occupants more frequently end up in the water than do those in larger boats because it is easier in some respects to misuse small boats. Landing in the water unexpectedly may be fatal.

The shock of a sudden plunge into cold water disorients many people. Add to this cumbersome clothing and, perhaps, an injury from the fall and you have an invitation to drowning. If you are wearing a life jacket when you unexpectedly land in the water, you increase your chances for survival.

Small Boat Stability

Obviously, anything you can do to avoid swamping or capsizing will decrease your chances for a boating accident. You can avoid swamping in two ways. First, don't go out in a small boat in rough water. Second, know how boats float and use this knowledge to your advantage.

When you go, regardless of the size of your boat, load it according to the weather. The rougher the weather, the more freeboard you need to avoid swamping. If your boat is less than 20 feet long, it has a capacity plate. Never exceed your boat's capacity in calm weather. Reduce its load if the weather deteriorates.

Things float because they displace a weight of water that is equal to their own weight. Boats stay on top of the water because their shapes are such that they sink into the water only far enough to displace their own weight of water. The heavier the boat, the farther it sinks into the water before it floats. This means that the less weight you add to a boat, the higher it will float in the water.

The stability of a boat, that is its ability to resist capsizing, depends upon its underwater shape and its centers of gravity and buoyancy. A boat's **CENTER OF GRAVITY** (CG) is the center of its total mass. A sturdy object is stable when its center of gravity is over its base and unstable when it is over a point outside the base.

The higher the center of gravity, the less stable the boat. Piling things in a boat or standing in a boat raises its center of gravity and lessens its stability. The lower the center of gravity of a boat, the more stable it is. The center of gravity of a boat varies with its load and where you place it as shown in figure 13-1.

Another consideration in the stability of a boat is its buoyancy. The buoyant force on a boat is equal to the weight of the water it displaces. The **CENTER OF BUOYANCY** (CB) is the center of the mass of the water the boat displaces. The center of buoyancy varies as a boat heels to one side or the other. In an unloaded boat, the centers of gravity and buoyancy are in a vertical line, and the boat is in a stable condition.

Figure 13-1 shows two small boats from astern. The first is empty. In the second a person is seated on a thwart. Notice that only the center of gravity has changed much from the first to the second. It has risen significantly and is farther from the center of buoyancy. The center of buoyancy has changed only slightly. If the elevated center of gravity moves off-center, which occurs, for example, if a person stands and leans to one side, it is difficult for the boat to right itself.

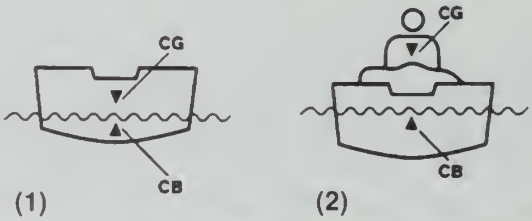


Fig. 13-1. Centers of Gravity and Buoyancy of an Empty and a Loaded Boat

Figure 13-2 shows the first boat of figure 13-1. This time the boat is heeled to starboard. The center of gravity does not change but the center of buoyancy shifts significantly. This shift creates a force on the starboard side of the boat that acts to bring the boat back to a level position. This force is greater in a flat bottom jon boat than in a round bottom canoe. The canoe will roll and swamp or capsize with a smaller shift in the center of buoyancy than will the jon boat. If you lean out over the side of a canoe, it may roll out from under you.

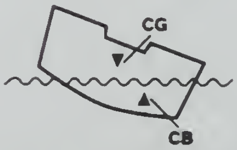


Fig. 13-2. Centers of Gravity and Buoyancy of a Heeled Boat

Figure 13-3 shows the second vessel of figure 13-1, but this time it is heeled to starboard. Notice that both the centers of gravity and buoyancy have shifted to starboard. The boat is unstable and may swamp or capsize. If the center of gravity shifts *outside* a boat, it will swamp or capsize.

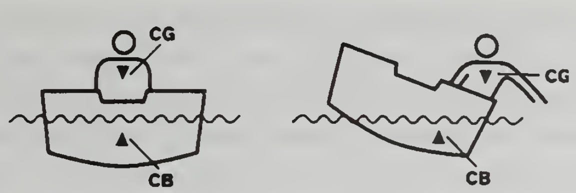


Fig. 13-3. How the Centers of Gravity and Buoyancy Shift When a Boater "Leans Out"

Boaters who are properly centered and seated low in a boat do not seriously disrupt the natural stability of the boat. If a boater stands up to shoot a gun, land a fish, reach for a pier, or for other reasons reaches too far to the side, the center of gravity may move outside the gunwale and the boat will swamp or capsize.

Maintain Three Point Contact

Once you take a seat in a small boat, stay seated. Don't lean over the side. When you enter a small boat, or if you need to move about, maintain three points of contact as in figure 13-4. Hold on to both sides of the boat and keep at least one foot on the deck. This keeps the center of gravity of the boat as low and as nearly centered as possible. It helps maintain the stability of the boat.

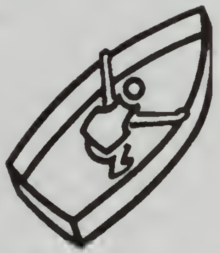


Fig. 13-4. Maintain Three Point Contact

Stay with Your Boat

As discussed earlier in this book, vessels less than 20 feet long have flotation built in at the factory. This means that if they capsize or swamp, they will stay afloat. If your boat capsizes or swamps, it is usually best to stay with it. Climb on it if possible. The colder the water, the more urgent it is that you get out of it. You may be tempted to swim to shore, but be careful. It is difficult to judge distances when you are in the water. It may be farther to shore than you think. Also, if you stay with your boat it is easier for people in another boat to see you.

PERSONAL WATERCRAFT

Personal watercraft (PWCs) have a variety of trade names including, Funjet, Jet Ski, Surf-Jet, Wave Runner, Wetbike, Sea-Doo, and Wetjet. The past few years have seen a rapid increase in the number of these motor vessels.

Strictly speaking, "personal watercraft" formerly included only those power driven vessels designed to carry one passenger, standing, kneeling, or sitting. This passenger steered the craft by handlebars such as those found on bicycles. The first sit-down model was introduced in 1987. By 1993, 94% of PWCs sold were sit-down models while only 6% were stand-up models. The commonly accepted definition of a personal watercraft today is "a vessel which uses an inboard motor powering a water pump as its primary source of power. In addition it is designed to be operated by a person sitting, standing, or kneeling on the vessel, rather than sitting or standing *inside* the vessel."

Larger models of PWCs are now on the market. They steer with handlebars and can carry as many as three seated people. This discussion of PWCs applies to them also.

Regardless of what these vessels are called, they are class A motorboats (boats less than 16 ft. in length); not toys. They are high performance motorboats and are subject to all the laws that govern motorboats. When you operate a PWC, always keep in mind that you are a boater. As such you must obey the laws governing our waterways just like any other boater. It is also good to keep in mind that your PWC is one of the smallest boats on the water. Although it is highly maneuverable, it is also highly unstable and less visible than larger boats.

Operator Responsibility

With certain exceptions, PWCs are subject to all the legal requirements outlined in chapter 2 of this book. This means their equipment must conform to all U. S. Coast Guard standards and regulations when they are used on navigable waters unless the manufacturer has applied for and has received an exemption or exemptions from the Coast Guard. Exemptions may cover such things as capacity plates, safe loading requirements, flotation, fuel systems, and powered ventilation.

PWCs must observe the Navigation Rules and all state and local laws and regulations. They must be properly registered and numbered and their certificates of number must be aboard when they are underway. Almost all PWCs are required to carry fire extinguishers.

Some states require that PWC operators be at least 14 years old. They may also require that a person be at least 16 before renting a PWC. Operators need both physical capability and maturity of judgment to operate these craft safely and responsibly.

Each person aboard must have a life jacket. Wear yours and have your riders wear theirs whenever you are underway. The chances are you and your riders will spend some time in the water. If the weather is cold, consider wearing a wet suit. Hypothermia can occur more rapidly than you may think. Since you will end up in the water, learn the procedures for righting the craft and reboarding before you go. If you can't swim, don't drive or ride on a PWC.

It is advisable to wear some kind of shoes or protection for your feet. This helps you keep your footing and avoid scrapes and bruises from underwater objects. You may want to consider wearing gloves to protect your skin and to aid in moving your watercraft during docking and loading.

As with any vessel, the responsibility for what happens to or on a PWC rests with the skipper. The skipper has responsibility for any damage the PWC may cause including damage from its wake. The skipper also is responsible to see that the PWC is operated legally. This includes such things as not operating your PWC at night if it does not have navigation lights or if there are local laws against it, and observing all the Navigation Rules for overtaking, crossing, and meeting situations.

Operating any vessel may be stressful. Operating PWCs can be even more stressful. Be aware that wind, glare, sun, and water can be fatiguing. To boat safely, you must stay alert. Don't exceed your limitations.

Be Respectful of Others

Beyond the legal responsibilities is the need to operate your PWC in a safe and courteous manner with regard for the rights of other people. These include people swimming, boating, skiing, and fishing. Irresponsible operators have caused state and local agencies to enact restrictive laws controlling PWCs. Don't add to the need for more laws and be sure to obey the laws of the state in which you are boating.

Be mindful that noise carries farther over water than over land, particularly when there are no other noises around. Since people want "peace and quiet" in early morning and late afternoon more than at other times, watch where you boat at those times. Stay away from areas where there are homes, campgrounds, or other places where people go for peace and quiet.

Some of the "don'ts" for operating a PWC include:

- Don't speed in a congested area,
- Don't speed in fog or stormy conditions,
- Don't operate in a swimming area,
- Don't operate close to dams,
- Don't cut through a regatta or marine parade,
- Don't cut across flats where people are fishing,
- Don't jump boat wakes, and
- Don't race up to something and swerve at the last moment.

You should never drink and operate a motorboat. On a PWC you are aboard an agile and responsive craft where conditions change with every wake or wave. Even small amounts of alcohol reduce your ability to respond effectively. You must be alert and in control.

The Coast Guard Auxiliary offers a Personal Watercraft course which the Personal Watercraft Industry helped develop. The course was written to aid the growing number of PWC operators and is taught by auxiliarists, often at boat dealerships. Ask your dealer to request the Auxiliary to conduct such a course.

Steering a PWC

PWCs are fun boats; quick and exciting. They are fast and highly maneuverable. Some can reach speeds of 40 miles per hour. Their power comes from two stroke cycle inboard engines that may have as much as 40 to 55 horsepower. A PWC engine pumps in large amounts of water and ejects it at a high speed through a special nozzle.

The nozzle turns to one side or the other, as in figure 13-5, to steer the boat. The operator and passengers also help steer by leaning and shifting their body weights much as they might do on a bicycle. The vessel reverses direction by dropping a "clam shell" barrier down behind the nozzle. This directs the force of the jet forward and the vessel reverses. It is advisable to shift to neutral and to stop before reversing.

This arrangement of an inboard engine and jet propulsion means that PWCs can accelerate rapidly, stop in short distances, or turn rapidly. Since their pivot points are roughly 14 to 20 inches forward of their engines, sharp turns are possible.

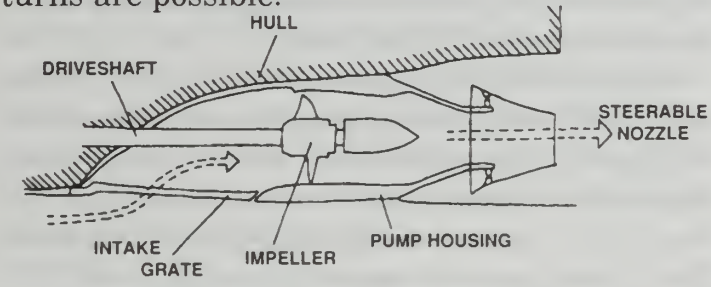


Fig. 13-5. Jet Drive System
(Drawing courtesy of Kawasaki Motors Corp.)

Some Safety Problems

The high speed and maneuverability of PWCs create special safety problems. For example, if a PWC is moving at fast speed, its operator may not see an object in the water in time to avoid hitting it.

Even at slow speeds, a PWC creates a lot of spray. This may blind its operator and cause an accident. Most PWC manufacturers recommend that operators wear goggles or wraparound eye protectors.

The ability of a fast moving PWC to accelerate or to change direction rapidly can produce a dangerous situation. Passengers and the operator may be thrown from the vessel and injured. A sudden change in direction may place the PWC directly in the path of an oncoming vessel. Operators should always look carefully for other boats and objects before starting and before making quick maneuvers. The speed of a PWC requires that operators be especially alert to what is around them.

On the water it is not a matter of looking both ways; it's looking all ways.

Never operate a PWC at high speed until you are thoroughly familiar with its operation. A beginning operator must learn that releasing the throttle or turning off the engine causes loss of directional control. Reducing power to avoid a collision may result in loss of control. You may run into the object you are trying to avoid.

If your PWC is not of the type that circles back when you fall off, it will have a lanyard and a "kill switch." Be certain to securely fasten one end to your wrist or life jacket and the other to its appropriate place on the ignition switch. If (and when) you fall overboard, this will shut off the engine and stop the boat. If you don't connect the lanyard, your vessel may continue on without you or it may circle back and run over you.

Learning to Operate a PWC

If you are learning how to operate a PWC, be cautious. Read the manual carefully and be sure that you understand it fully. Pay particular attention to procedures for reboarding in deep water.

Before starting up, make certain that the water is deep enough to avoid drawing sand into the intake. It can damage the impeller

Fig. 13-6. Jumping a Boat's Wake May Be Fun But *IT IS DANGEROUS.*
(Photo courtesy The Tuscaloosa News, Tuscaloosa, Alabama.)

and may injure someone when ejected from the nozzle. Never operate your PWC in water less than two feet deep. Also, before starting up check to see there are no objects in the water that might enter the intake.

Should the intake become clogged, stop the engine before you try to clear it. Do not reach into the nozzle when the engine is running. Keep your hands, feet, hair, and clothing away from the intake when the engine is running.

Start slowly and get the feel of the vessel. The vessel responds differently to different operators. Its operation with a small person is much different from what it is with a heavier person. It operates differently with a full load than with a sole operator. If it is pulling a skier (which is illegal in some places) or another PWC, it may respond in a sluggish manner. The resulting loss of control may create a hazardous condition.

A beginning operator must concentrate on learning how to control the boat. As a result, the operator is not fully aware of things such as nearby swimmers, other vessels, and immovable objects. It makes sense to operate slowly until you master control of the vessel.

Some PWCs are self-righting. Others require special techniques to right them after they turn over. Operators should be thoroughly familiar with the procedures as outlined in their manuals before operating the vessels. Rental boat operators should see that renters are familiar with the procedures.

It's good sense to stay in sight of land whether you are alone or not. It's also good sense to watch your gasoline use. Observe the 1/3 rule. Use no more than 1/3 of your fuel on the trip out, keep 1/3 for the trip back, and save the other 1/3 in reserve.

HYPOTHERMIA

Hypothermia is a major killer in aquatic mishaps. It is a reduction of the body's *core* or *internal* temperature below where normal biological functions can occur. Hypothermia is not "freezing to death" nor is it frostbite. It can kill you at temperatures well above freezing. In hypothermia your body loses heat more rapidly than it can replenish it.

Hypothermia is a serious, life-threatening condition. It is difficult to treat and requires expert care. If you suspect hypothermia, seek prompt and competent medical attention.

Anytime your body is unable to maintain its normal temperature, you are at least mildly hypothermic. Most people have experienced mild hypothermia by overexposure to winter weather. It can occur at other times of the year in strong winds, especially if your clothing is wet. It occurs frequently in mild form when you swim in cold water.

Hypothermia occurs most rapidly when your body is immersed in cold water. The shivering you may experience is one means your body has to keep itself warm. The colder the water, the more rapidly hypothermia occurs. But it can occur in water as warm as 80°F if you are exposed to it for a long enough time. In water at 50°F, the predicted survival time is 1.5 to 3 hours.

The 50-50 "rule" emphasizes the rapidity with which hypothermia can occur. You have only a 50-50 chance to swim 50 yards in water at 50°F. Another "50" rule says a 50-year old person has only a 50-50 chance of surviving for 50 minutes in 50°F water.

Stages in Hypothermia

Your body burns food to give it the energy it needs to operate and to maintain its temperature. You give off excess heat by radiation and the evaporation of perspiration. When your body cools down, blood moves from its surface and large muscles to vital organs (brain, heart, lungs), and you burn stored food to generate more heat. One sign of the diversion of blood is the appearance of "gooseflesh." Another sign is shivering.

As your core temperature falls and your body's resources decrease, your shivering slows and then stops. Your body begins a systematic shutdown. It shuts down first on the periphery (arms and legs) while it seeks to maintain a constant temperature in its core. If you have been drinking, your capillaries are dilated. You will lose heat more rapidly, and the process will speed up.

As cooling continues, speech becomes slurred and incoherent. You become increasingly lethargic and uncoordinated. Respiration becomes shallow and erratic. You lose consciousness and eventually die.

Hypothermia can occur in a strong cold wind. It occurs more rapidly in women than in men because of their smaller body sizes. It occurs even more rapidly in children due to their smaller sizes and because they usually have less body fat.

Hypothermia occurs more rapidly when you are wet than when you are dry. It occurs even more rapidly if you are immersed in water. Water conducts heat away from your body. The water need not be "cold" to do it. Table 13-1 gives approximate survival times in water of various temperatures.

Prevention of Hypothermia

Prevention of hypothermia is easy. Most of the measures to combat it are "common sense" measures that you would normally take anyway.

Conserve Your Heat. The simplest thing to do is to avoid situations that promote loss of body heat. Usually, this means keep dry and out of the wind. If you fall overboard, get out of the water as soon as possible. Getting out of the water helps reduce the rate of heat loss.

Clothing Makes a Difference. The clothing you wear makes a difference in your rate of heat loss. Synthetic fibers are effective in reducing heat loss when they are dry. They afford virtually no protection to heat loss when wet. Wool retains a higher degree of its insulating properties when wet than most other fabrics.

Increase Your Energy Reserve. Never go into a potentially hypothermic situation without having eaten a good meal. This is good practice for boating activities and anything that involves working or playing out of doors especially in the cold.

Table 13-1

Approximate Median Lethal Exposure Times			
Water Temp. (F°)	Time in Hours		
	Floating with PFD	Treading Water	Swimming
35	1.75	1.25	.75
45	2.50	1.75	1.00
55	3.50	3.00	2.00
65	7.75	5.75	4.50
70	18.00	13.00	10.00

Activity and Hypothermia

Your life jacket may help you ward off hypothermia. "Jacket" styles offer better protection than "bib" styles. Besides trapping warmed water between it and your body, a life jacket helps you stay afloat with a minimal expenditure of energy. If you are not wearing a life jacket you may need to tread water to stay afloat. This uses energy and hastens hypothermia. Tests show that the average rate of heat loss of a person treading water is about 34 percent faster than for the same person holding still in a life jacket.

Floating and Heat Loss. If you can't swim and aren't wearing a life jacket, you may have to use another technique to survive. This involves floating with your lungs full of air. You immerse your head in the water and you raise it every ten to fifteen seconds to breathe. By this means, even non-swimmers can delay the possibility of drowning for many hours. But it presents problems in cold water. People who use this technique and are immersed in 50°F water lose heat about 82 percent faster than if they were holding still in a life jacket. Better wear a life jacket anytime you are underway!

Swimming and Heat Loss. If your boat capsizes, your first impulse may be to swim to shore. This is dangerous at any time and more so if the water is cold. The more you swim, the more heat your body generates. This heat is lost rapidly in the cold water. In a short time your body may have exhausted its ability to generate heat.

Get Out of the Water

Studies show that the average person swimming in a life jacket cools 35 percent faster than when holding still. Instead of swimming to shore, climb on your boat. You may be able to balance your heat loss with the heat your body can generate. Water conducts heat away from your body many times more rapidly than air at the same temperature as the water.

If you find yourself in the water, do what you can to conserve your heat. Keep your clothes on. They provide some insulation from heat loss. Air trapped in your clothing also helps insulate you from heat loss.

Do not struggle or try to swim. When you struggle or swim, you lose the trapped air in your clothing, and the process of losing heat speeds up. Insulated clothing, minimal movement, clear thinking, and a life jacket provide the best possible defenses against cold water.

The HELP Position

If you are wearing a life jacket, draw your knees up into a **HELP** (Heat Escape Lessening Position) position (fig. 13-7). Make your body as compact as possible. If there are two or three people in the water, huddle together so you can conserve your heat. Move about as little as possible.

If you are wearing a type III life jacket, don't use the HELP position. You may be turned face down. Instead, bring your legs tightly together, and keep your arms tight to your sides. Lean your head back to keep your face out of the water.

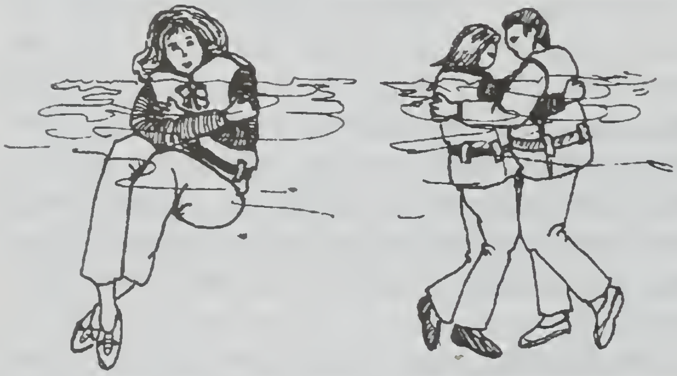


Fig. 13-7. Conserving Body Heat

The greatest heat loss from your body is from your head. Keep it above water, if possible. The next greatest loss is from your armpits and sides. Thus, in the HELP position, you press your arms against your sides, draw up your legs, and keep your head above water.

Helping Hypothermic People

If you try to rescue people with hypothermia, be careful. Their energy resources are minimal. Have them do as little as possible to help you in their rescue. They may deplete what energy reserves they have left. Hypothermic people have died after rescue because of their exertion during the rescue.

If you get wet, avoid the wind. A wet body in wet clothing can generate enough heat to maintain its core temperature for a time. If the wind carries away the heat trapped in wet clothing, your body must replace it. If you can't replace it rapidly enough or if you exhaust your reserve food supply, your body temperature will drop farther. Wet clothing without wind is a less effective insulator than dry clothing. It is better, though, than it would be if wind were present.

How You Can Help

When helping a hypothermic person, always remember that hypothermia is a serious medical problem. Get medical attention as soon as possible.

Meanwhile, remember how fragile the person is when in a hypothermic state. Make the person as comfortable as possible.

If you have a VHF-FM radio aboard your vessel, contact the Coast Guard as soon as possible in any life-threatening emergency. Tell them your problem and request that they have an ambulance meet you at the nearest landing place.

Then ask the Coast Guard to advise you on first aid methods. They have the specialized knowledge that you need and will guide you in rewarming the victim.

MOTORBOATS AND SAILBOATS

We do not intend to teach you how to be a sailor in this chapter. We couldn't in the limited space available if we wanted to. Sailing involves complex skills and knowledge. In this part of the chapter, we will try only to increase your understanding of the problems experienced by sailors and what you can do to avoid being a part of their problems. If you would like to know more about sailing, we recommend that you take our *Sailing And Seamanship* course. Your instructor can tell you when the Auxiliary will offer the course.

Even if you are not part of a sailboater's problem, you may someday become the solution to a problem of a sailboater. You may find it necessary to go to help a sailboat or a sailboater as you would help a powerboater in need. Giving help to a sailboat in distress involves a unique set of problems.

Unique Problems of Sailboaters

Sailboats are at the mercy of the wind. This causes many of their problems.

Square Rigged Vessels. It has been only in the last two centuries that boats could sail easily toward the wind. Square rigged vessels, such as the Mayflower, the Niña, the Pinta, and the Santa Maria, sailed mainly downwind or nearly so. By complicated maneuvers, they could sail in other directions but, in the main, the wind blew them along.

Because of this, sailors used their understanding of the general directions of the earth's winds to take them to and from their destinations. Many of these winds became known as the trade winds. Columbus took advantage of the trade winds to sail from Africa to the new world. He used the prevailing westerly winds to return to Europe.

Tacking. The triangular sails of modern sailboats are a relatively recent invention. They enable a vessel to sail in directions other than downwind. In sailing downwind, a sailboat can maintain a fairly straight course if the wind is strong enough and if the wake of passing vessels is not too disturbing.

When a sailboat attempts to sail toward the wind, it must constantly change its direction. It first sails on a leg with the wind coming across one side of the boat and then turns in a new direction so the wind comes across

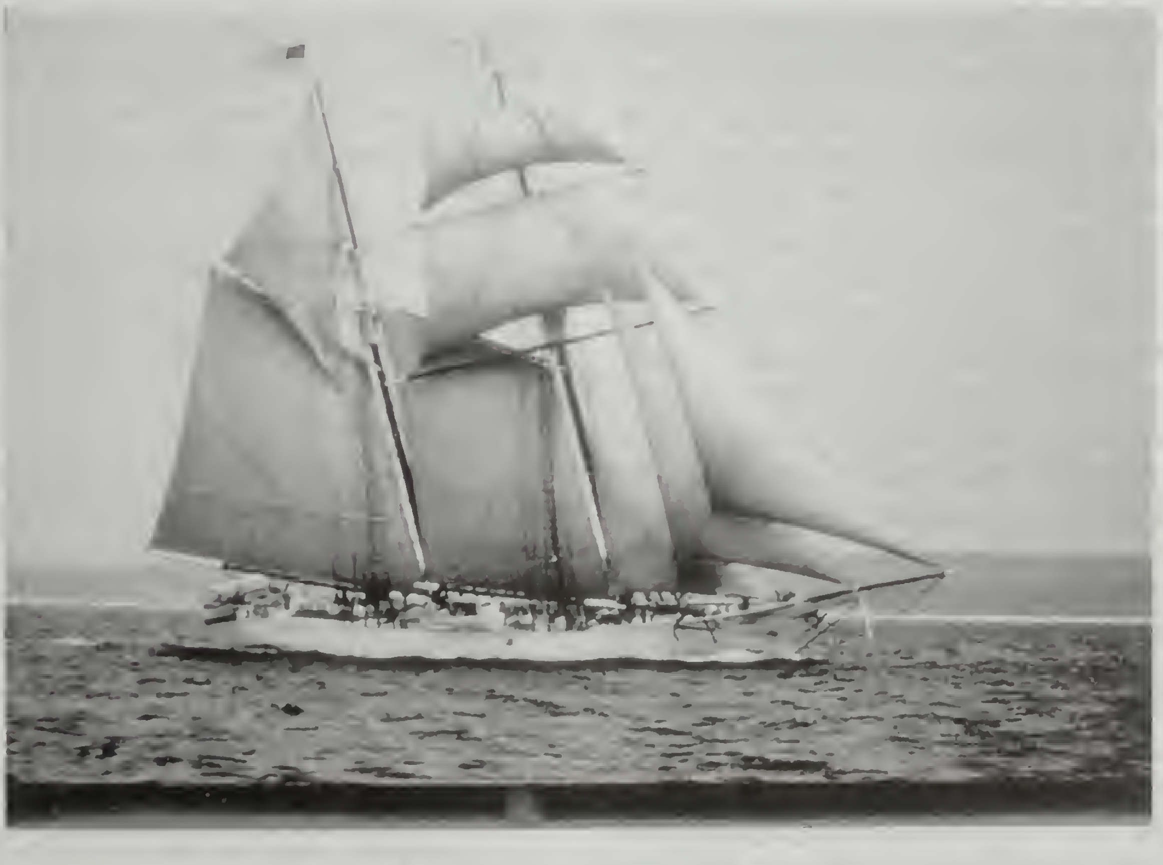


Fig. 13-8. A Schooner with Square Rigged Top Sails
(Courtesy of Phil Davis, Jr.)

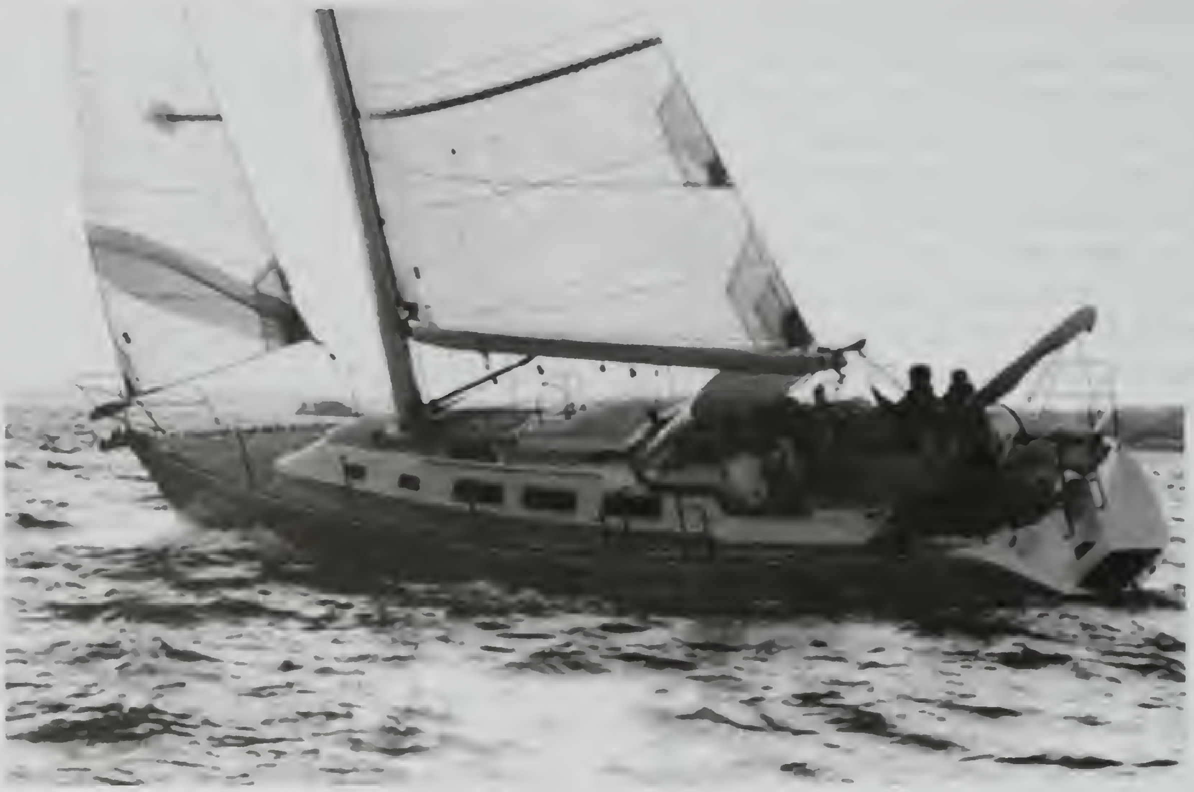


Fig. 13-9. A Sloop-Rigged Sail Boat
(Courtesy of Freedom Yachts)

the other side. This means it sails a zigzag course by a series of **TACKS**. It keeps up these maneuvers, always coming closer to its destination until it finally arrives. This process of moving toward a destination in a zigzag manner is called **TACKING**.

By tacking, a sailboat can travel upwind. The closest any one leg of its zigzag course can come to the direction from which the wind is blowing is usually 45° (fig. 13-11). Thus, for practical purposes, there is a 90° arc through which the boat cannot sail. Powerboaters need to know that sailboats move upwind by tacking so they will be alert to sudden changes in direction of sailboats sailing upwind. Under all circumstances, powerboaters should give sailboats the maximum room in which to operate. The narrower the passageway, for example an inlet or a channel, the more the powerboater needs to exercise caution.

Mooring and Anchoring. Sailboats have other problems not experienced by powerboats. In the chapter on Handling Your Boat, problems of mooring and anchoring a powerboat were discussed. These are simple problems for powerboaters but complicated maneuvers for sailboaters. The sailboater must approach the

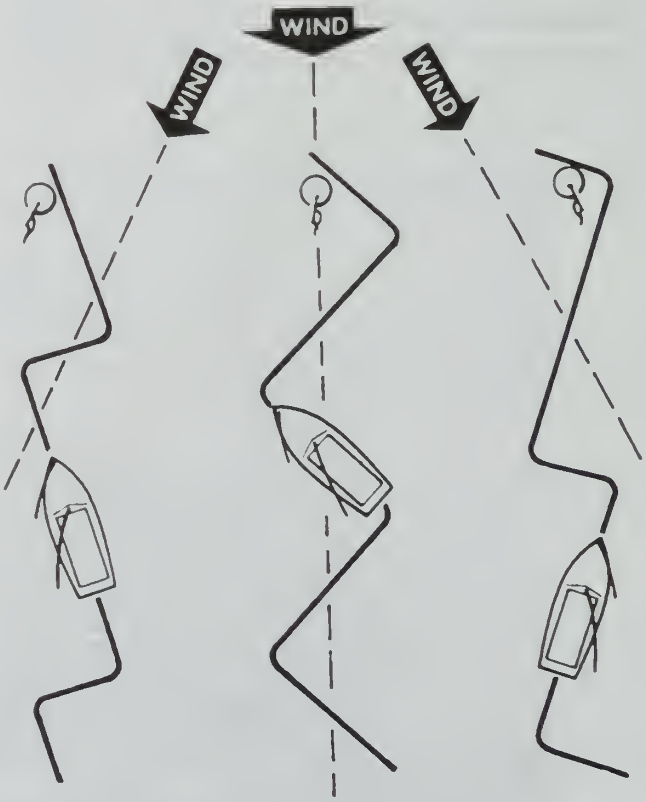


Fig. 13-10. Tacking to a Windward Objective

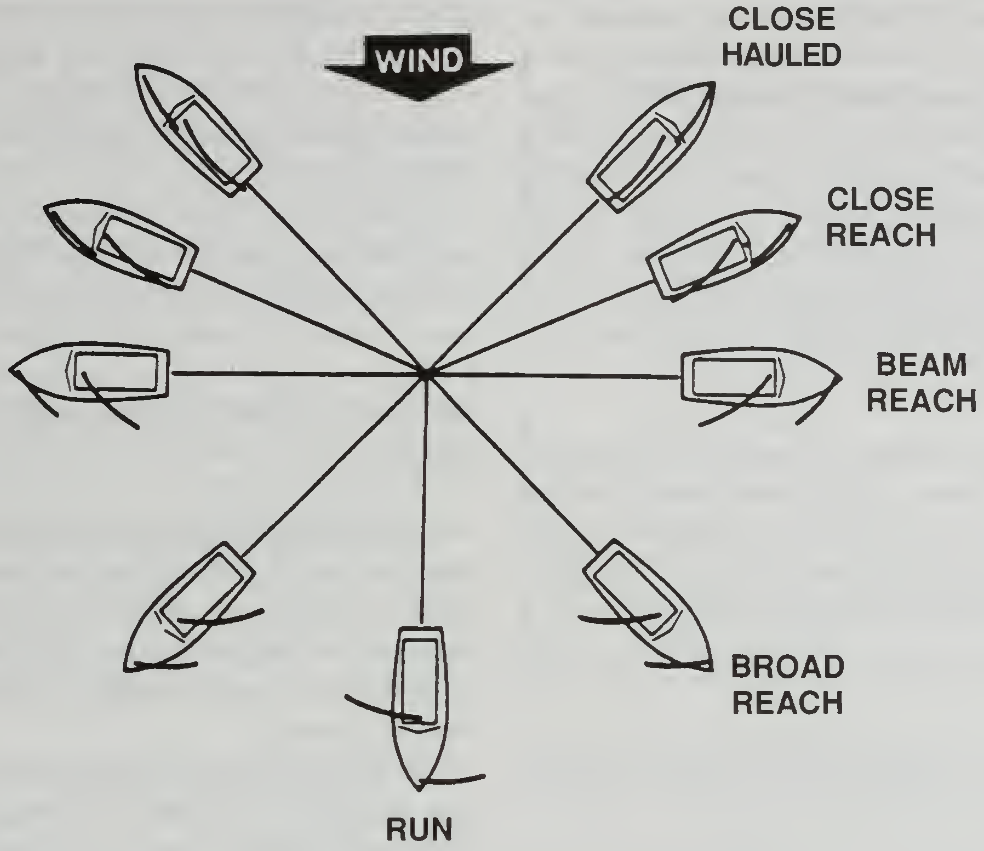


Fig. 13-11. The Directions in Which a Modern Sailboat Can Sail

mooring or anchorage sailing into the wind. The maneuver must be timed precisely for two reasons. First, as the boat loses headway, it becomes less and less easy to control by its rudder. Second, the boat must arrive at its mooring at the moment its forward progress stops. The wake of a passing motor boat may seriously interfere with the mooring and anchoring.

When There Is Little Wind. Wakes from powerboats not only make mooring and anchoring difficult to perform, they also adversely affect sailboats when there is little wind.

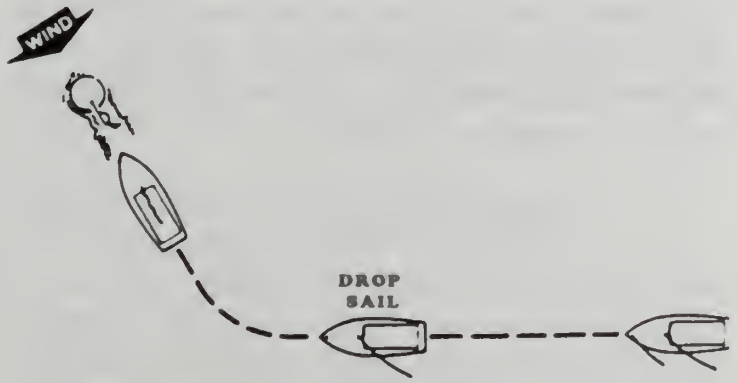


Fig. 13-12. Approaching a Mooring

Many sailors, particularly inland boaters, find that it is a shortage of wind that most frequently taxes their patience and skills. When drifting slowly along, a sailboat responds only sluggishly to its helm. This makes it difficult to maneuver. The problem is compounded when the boat is confined to a narrow channel due to its draft.

Wind and Wake. Slowly drifting sailboats are particularly sensitive to disturbances created by the wakes of passing powerboats. Besides being uncomfortable as the boat bobs helplessly on a powerboat's wake, the wake can seriously reduce the already slow boat speed and momentarily disrupt directional control of the craft.

Bobbing in a wake also can cause serious damage to the boat through an accidental **JIBE**. In an accidental jibe, the mainsail may move from one side of the vessel to the other in an uncontrolled manner. If the jibe is abrupt enough, damage can occur to the vessel. Accidental jibes have caused serious personal injury and can dismast sailing vessels.

A rocking boat is dangerous to everyone on board. Accidental falls can occur. Scalding or a messy situation can result from spills in the galley. Passing powerboats should keep a safe distance from sailboats and keep their wakes to a minimum when passing. This may mean that the powerboat should slow enough that it comes down off its plane and moves as a displacement vessel at idle speed while passing a sailboat.

Blocking the Wind. If you have watched large sailboats race, you have seen some of the maneuvers they perform to gain advantages over their competitors. Actually, the outcomes of races usually depend on the winning skippers' superior skills. It's one ups-man-ship on the water.

One of the maneuvers is to block the wind from a competitor's vessel. The blocker moves into a position upwind of the vessel being blocked and keeps the full force of the wind from reaching it. As a result, the blocked boat slows. By the time it regains its speed, it may have lost the race.

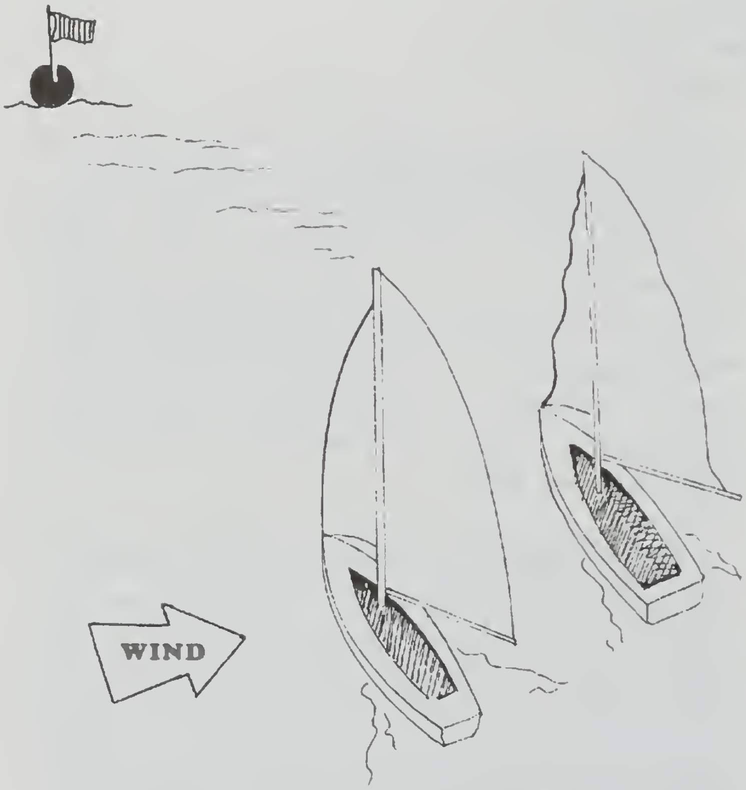


Fig. 13-13. Blocking the Wind From a Competitor

The same result can occur when a motorboat moves upwind of a sailboat. The larger the motorboat, the greater the blocking. If the wind is nearly calm, the sailboat may come to a stop or move in an uncontrolled manner. Whenever possible pass downwind of a sailing vessel.

Obscured Vision. The sails of a boat can obscure a skipper's vision, and the skipper may not see nearby vessels. This happens to sailboats and to **SAILBOARDS**. (Sailboards are surfboards with sails on them. They are used for **WINDSURFING**.)

It is hazardous to approach a sailboat from any direction in which its skipper does not have you in full view. It is even more hazardous to approach a sailboard. Not only is the windsurfer's vision obscured, but frequently the windsurfer ends up in the water.

Special Navigation Rules for Sailboats

The unique problems of sailboats explains why they have special consideration in the Navigation Rules.

Priority of Sailboats. One very important Navigation Rule creates an order of precedence for one vessel approaching another. This rule makes vessels not under command, vessels restricted in their ability to maneuver, fishing vessels, and sailing vessels stand-on to powerboats that are passing them.[1]

In other words, power-driven vessels have the lowest priority and must keep out of the way of other vessels they are passing. This includes sailboats and other vessels that are unable to maneuver easily.

---

[1] See chapter 6, The Rules You Must Follow, for a discussion of these terms.

Since they are more maneuverable, sailing vessels must keep out of the way of vessels not under command, vessels restricted in their ability to maneuver, and vessels engaged in fishing. Sailing vessels lose their priority when they are overtaking other vessels. If the sailing vessel is operating its engine, it also loses its priority. It is no longer a sailboat; it is a motor vessel.

Sailing Races. During a sailing race, special complex rules are in effect. These have to do with the overlap of two boats and the resulting right of way, the amount of room that one sailboat must give another one at a turning point, stand-on status, and many others. Sailboat skippers use these rules to gain advantages over their opponents. It's all in the game!

Sailboat racing is such a finely tuned operation that it is easily interfered with by outside forces. This means that powerboats must avoid making wakes near race courses. Those powerboats that attend the racing boats to officiate the race and to assist if a crew member falls overboard should stay well behind to avoid making wakes that might change the outcome of the race. Powerboats should swing wide at a change in the direction of the course to keep their wakes from crossing over to the other side of the course. In sailboat races, it is the small things that determine the outcomes.

Crew Member Overboard

In boating there is always a risk of a person falling overboard. For this reason all hands should wear life jackets when aboard. Although falls overboard happen on powerboats, they occur more frequently on sailboats due to their construction and the need for crew members to move about. During foul weather, crew members often wear safety harnesses and are secured to the vessel by lines.

Retrieving an Overboard Person

Retrieving a person overboard from a power boat is a difficult maneuver. It is more complicated when the person has fallen from a sailboat. The boat must come about and return to the crew member in the water. This is often a difficult maneuver that must be done rapidly if the water is cold.

Table 13-2

Order of Precedence of Vessels
A vessel is stand-on to all vessels below it in the list.
• Overtaken Vessel • Vessel Not Under Command • Vessel Restricted in Ability to Maneuver • Vessel Constrained by Draft (International Rules Only)* • Fishing Vessel • Sailing Vessel • Power Boat • Seaplane
* The Inland Rules do not recognize "vessels constrained by draft."

The first person to see another fall from a vessel, immediately calls out "man overboard." This person then has responsibility for continuously pointing to the person in the water as the boat prepares to come about as in figure 13-14. As soon as the alarm sounds, throw a life ring or other flotation device to the stricken person.

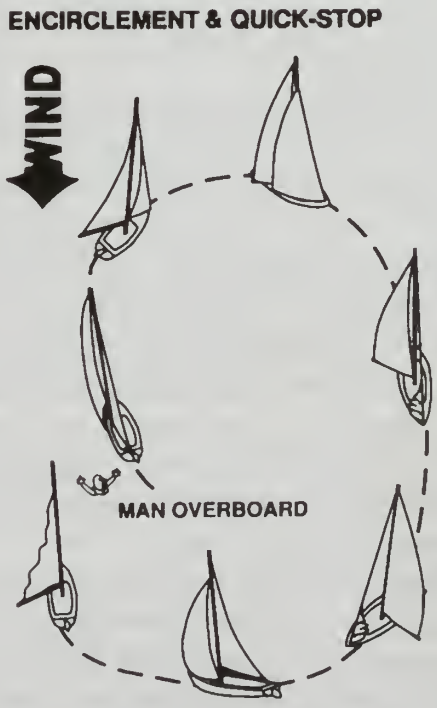


Fig. 13-14. Approaching a Person in the Water

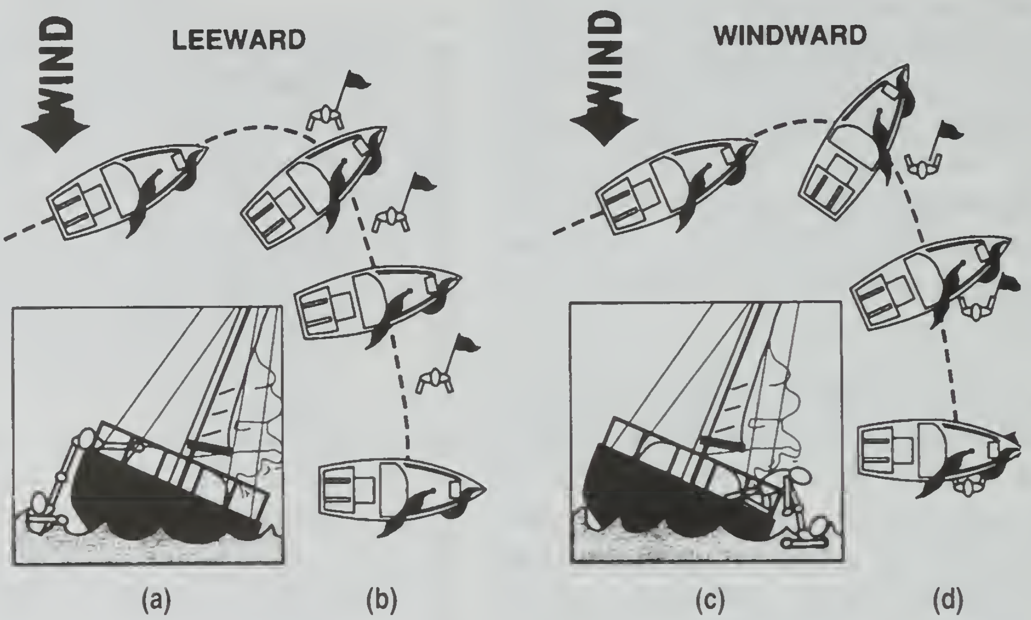


Fig. 13-15. The Heeling of a Vessel in a Leeward or Windward Approach

Upwind or Downwind? Bringing a sailing vessel about and returning to the exact place where the person is in the water is difficult. When it is done successfully, there are still problems. One of these is, "Should the approach to the person be from upwind or downwind?"

If from downwind, there is always the chance that the boat will be blown away from the person in the water (fig. 13-15b). If from upwind, there is a risk of running over the person (fig. 13-15d). The approach from downwind is usually safer.

If the approach is from downwind, though, the wind may cause the vessel to lean or **HEEL**. This means that it is farther from the gunwale to the water's surface than if the approach were from upwind (fig. 13-15a).

If the approach is from upwind, the distance from the gunwale to the water's surface is less than in a downwind approach. But there is another problem. The boat's sails will be blown to the same side of the vessel as the person in the water and may make it difficult to effect a rescue (fig. 13-15c).

Regardless of which choice is made, as the boat nears the person in the water, any mechanical propulsion device such as an auxiliary engine should be turned off. A moving propeller close to a person in the water is a dangerous object.

Bringing the Person Aboard. If all goes well, there is still the problem of retrieving the person in the water. This may be difficult on a sailboat because of its high freeboard. Boosting a person aboard, especially if the person is unconscious, is difficult without some sort of mechanical device and a sling. If only one person is left on board, it may be impossible.

If you are power boating and see a person fall overboard from another vessel, move in to help. Be careful that you do not interfere with the rescue attempts of the crew of the other boat. If possible, ask if you can help. If it is obvious that you can give more adequate help than the crew of the other vessel can, move in and help. If necessary, take the person aboard your boat. You can transfer the person from your boat to the other vessel on the scene or at a safer location.

Righting a Sailboat

Large sailboats capsize infrequently although it can happen in gusty weather. When they do experience a "knockdown," they usually right themselves because of their heavy keels. This does not mean that a knockdown is free of negative consequences. These may include injury to people on board and, perhaps, to one or more of them going overboard.

If you witness a knockdown, go to the vessel to see if you can help.

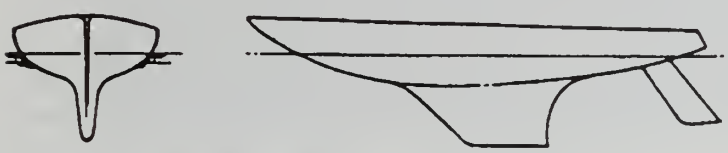


Fig. 13-16. Ballast Keel Hull

Small sailboats capsize more frequently than large ones, and when they do, they usually do not right themselves. You need special knowledge and skills to right them. If you see a capsized sailboat, offer to help but do no more than requested.

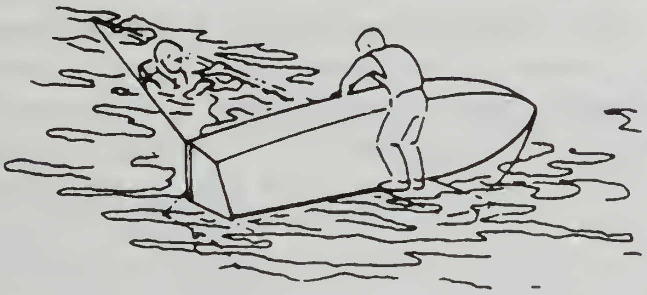


Fig. 13-17. Righting a Capsized Boat

If you are asked to help, be careful as you approach the boat. There will probably be people, equipment, and rigging in the water. You don't want to get snarled in the rigging.

In any rescue attempt, first see if everyone is accounted for. Someone may be trapped under the rigging. Help those in the water to board your boat. If the weather is cold, do this as quickly as possible to avoid possible hypothermia. Tend to the people before you attempt to retrieve equipment.

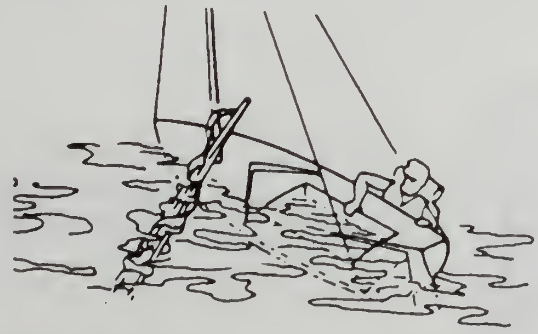


Fig. 13-18. Bailing the Righted Boat

The skipper of the boat probably knows what to do to right the vessel. Usually, this consists of lowering the sails, standing on the keel, centerboard, or daggerboard while holding on to the gunwale, and leaning backward. This is usually enough to bring the boat to an upright position. The process of bailing can begin. When possible, a lightweight crew member should climb aboard to finish bailing.

If the vessel cannot be righted, stand by to warn others of the danger and to help a salvor locate the vessel. Use your VHF-FM radio to summon help.

Righting a Sailboard

Sailboards capsize frequently, and their operators probably know what to do to right them. If you see a sailboard capsize, watch to see if the operator is injured. Also, see if the operator can right the craft. Under some circumstances it is difficult to right a sailboard. This can occur with a novice operator. If the operator can't right the craft, offer to help.

In excessively windy weather, the skipper may not be able to right the craft. Again, if this happens, offer to help.

CARBON MONOXIDE POISONING

Carbon monoxide is a colorless, odorless, highly poisonous gas. It has about the same weight as air and mixes readily with it. It forms when there is incomplete combustion of hydrocarbon fuels such as gasoline and diesel fuel and other carbon compounds. About 10 to 12 percent of the exhaust gas of an internal combustion engine is carbon monoxide. The engine on your boat produces carbon monoxide when it is running. Exposure to carbon monoxide can be fatal since it reduces the ability of the blood to absorb oxygen.

Symptoms of Carbon Monoxide Poisoning

Carbon monoxide is toxic in concentrations as small as one part in 100 parts of air. Its symptoms include drowsiness, headaches, dizziness, weakness, nausea, fainting, and coma. It eventually results in death.

Most people know that they should not run their automobile engines in enclosed spaces such as a garage. What they may not know is that the engine in their boat produces the same gas. If you experience any of the symptoms associated with carbon monoxide poisoning, such as constant headaches, when you boat, you should consider the possibility that you are being exposed to carbon monoxide.

Carbon Monoxide and Ventilation

You may know that it is possible for a moving station wagon to pump exhaust gas in through its rear window. In some instances, people in the back seats have died from the carbon monoxide that was drawn into the vehicle from the engine exhaust.

The same condition can exist in the cockpit of a vessel that is enclosed on all sides except the stern. There are also other ways carbon dioxide can enter your vessel.

The carbon monoxide that may kill you may not come from your boat's engine. It may come from the exhaust of your generator's engine, if your boat has one. It may even come from a boat in an adjacent slip. If you experience any of the symptoms of carbon monoxide poisoning, search for the cause.

One owner of a new boat had it equipped with a carbon monoxide detector. This alarm sounded continuously while the engine was operating and for several minutes after it was shut down. A representative of the boat manufacturer suggested that the alarm was faulty.

The headaches, nausea, and disorientation the owners and their children experienced all pointed to carbon monoxide poisoning, so the advice was ignored. The owners surmised that engine fumes might be entering the cabin through the head ventilation exhaust. This exhaust was located near the engine exhaust. When the installation was modified, the problem disappeared. Check valves are now installed in the ventilation ducts of these boats.

Preventing Carbon Monoxide Poisoning

You can prevent carbon monoxide poisoning by making certain that your engine compartment is well ventilated and that the ventilation system is operating properly. In addition, be wary of completely enclosing your vessel if it was not designed for this purpose. Above all, be alert to the symptoms of carbon monoxide poisoning. Should they occur, immediately suspect the presence of carbon monoxide and search for its avenue of entrance to your boat.

It is a good idea to install a carbon monoxide detector in all closed spaces people occupy on your vessel. The U.S. Coast Guard recently stated, "Improvements in technology and reliability of carbon monoxide gas detectors have reached the point where their installation in accommodation spaces should be considered by all safety conscious recreational boaters."

A FURTHER INVITATION

We urge you to have an auxiliarist give your vessel a free Courtesy Marine Examination. It will cost you nothing but a small amount of time. It may make your boating safer and more enjoyable.

We would also like to again invite you to take another one of our courses such as Sailing and Seamanship, Basic Coastal Navigation, or Advanced Coastal Navigation. Better still, join the Auxiliary and take advantage of the training we can give you.

FLOAT PLAN

Date: ____________

Complete this plan before you go boating. Leave it with a reliable person either at a marina or elsewhere. Ask that person to notify the Coast Guard or other local authority if you do not return as scheduled.
DO NOT FILE THIS PLAN WITH THE COAST GUARD.
Cancel the plan when you return.

Name of your vessel ______________________________
Your name ______________________ Telephone ____________
Address ______________________________

DESCRIPTION OF VESSEL

Type ______________________ Color ____________
Color of Trim ____________ Registration Number ____________
Length ________ Sails ________ Make ________
Engines: Number ________ Type ________ Horsepower ________
Fuel Capacity: ________ Canvas Top? ________ Color of Top? ________

SURVIVAL EQUIPMENT (Check as appropriate)

PFDs ________ Flares ________ Mirror ________ Signal Flag ________
Smoke Signals ____________ Signalling Flashlight ____________
Food ______________________________
Emergency Water ______________________________
Anchor ________ Amt. of Line ________ Paddle ________
Radio YES/NO ________ Type ________ EPIRB ________ Frequencies ________
Raft or Dinghy ______________________________

OTHER PEOPLE ON BOARD

Name	Age	Address & Telephone Number

TRIP DETAILS

Depart: Date ________ Time ________ **Return:** Date ________ Time ________
Going to: ____________ VIA ____________
Return VIA ____________ Latest Time of Return ____________

IF TRAILERING:

Auto License ________ State ________ Type & Make ________
Trailer License ________ State ________ Color of Auto ________
Where Parked? ______________________________

NOTIFICATION

If Not Returned by ______________________ (time) **Call the Coast Guard**
at ______________________________ or
Local Authority at ______________________________ .

U. S. Coast Guard District Offices

FIRST COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
First Coast Guard District
408 Atlantic Avenue
Boston, MA 02110-3350

SECOND COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
Second Coast Guard District
1222 Spruce St., Room 2.102D
St. Louis, MO 63103-2832

FIFTH COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
Fifth Coast Guard District
Federal Building 431 Crawford St.
Portsmouth, VA 23705

SEVENTH COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
Seventh Coast Guard District
Brickell Plaza Federal Bldg.,
909 S. E. First Ave.
Miami, FL 33131-3050

EIGHTH COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
Eighth Coast Guard District
Hale Boggs Federal Bldg., 501 Magazine St.
New Orleans, LA 70130

NINTH COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
Ninth Coast Guard District
Anthony J. Celebreeze, Federal Building
1240 E. 9th St.
Cleveland, OH 44199

ELEVENTH COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
Eleventh Coast Guard District
Union Bank Building, RM 905,
400 Oceangate Blvd.
Long Beach, CA 90822-5399

THIRTEENTH COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
Thirteenth Coast Guard District
915 2nd. Ave. Federal Bldg.
Seattle, WA 98174 -1067

FOURTEENTH COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
Fourteenth Coast Guard District
Federal Building, 300 Ala Moana Blvd.
Honolulu, HI 96850-4982

SEVENTEENTH COAST GUARD DISTRICT

COMMANDER, U. S. Coast Guard
Seventeenth Coast Guard District
P. O. Box 25517
Juneau, AK 99802-5517

INSTRUCTIONS FOR USING A COURSE PLOTTER

The course plotter is a protractor, designed to measure courses and bearings on charts. It is particularly useful in small boats since it needs little space.

To use the plotter, first *estimate* the direction of the course line. When the course is somewhere between North and East, it must be between 0° and 90°. When between East and South, it is between 90° and 180°. Between South and West, it is between 180° and 270°. And between West and North, it is between 270° and 360°.

Measuring Courses and Bearings.

To measure a course or a bearing, place a long edge or a line of the plotter along the course line or bearing. Now, slide the plotter along this line until the bull's eye is over a meridian of longitude. Read the course or the bearing from one of the scales where the meridian intersects them. Only one of the numbers on the four scales will be close to your estimate of the direction of the course line. This number is its direction.

When the course or bearing nears North or South, it becomes difficult to slide the bull's eye to a meridian. In this case, slide it to the nearest parallel of latitude. Now, use this line to read your course direction or bearing. Again, the scale reading closest to your estimate is the correct direction.

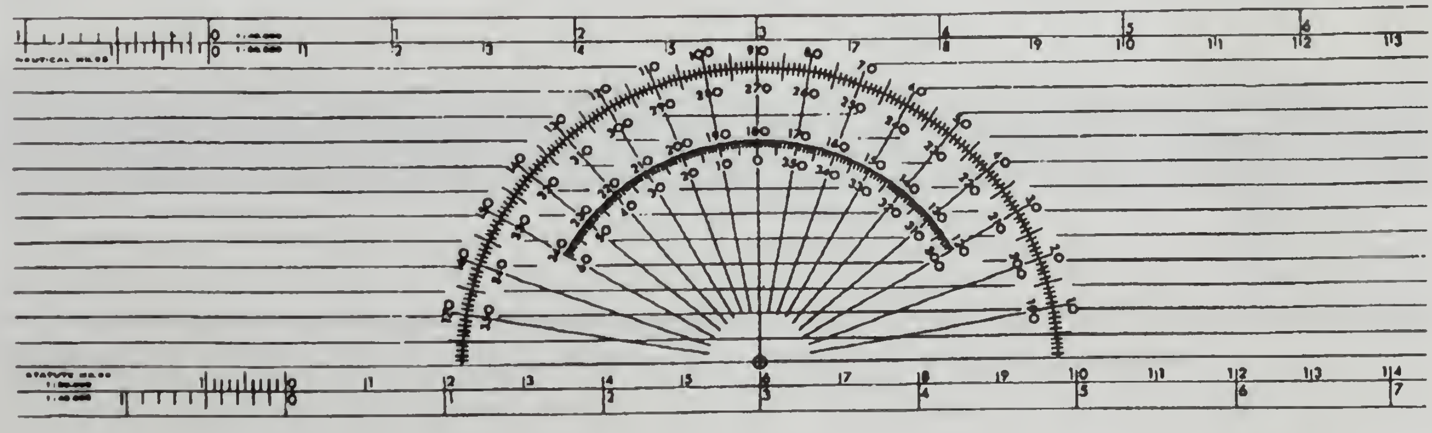
Remember, if you place the bull's eye on a meridian, you must use this meridian to read the course direction. If you place the bull's eye on a parallel, use that parallel to read the course direction.

Drawing a Course or Bearing from a Given Point.

To draw a course or bearing from a given point, place the plotter in the general direction of the desired course or bearing. Next, place the point of your pencil on the point. Now, slide the plotter until one of its edges touches the point and the bull's eye is on a meridian. Then, while keeping the plotter against your pencil and the bull's eye over the meridian, slide the plotter up or down. When you have adjusted the plotter to the desired angle, draw the course or bearing line along its edge. Again, if your course or bearing is nearly North or South, use a parallel of latitude.

Extending a Course Line.

You can easily extend a course line beyond the end of the plotter. First, spread your dividers and place them on the course line. Next, place one edge of the plotter against the dividers. You can now slide the plotter along the points of the divider and draw the extended course line.



English-Metric and Metric-English Conversion Table[†]

English to Metric:			*Metric to English:*		
When you know	***Multiply by***	**To find**	**When you know**	***Multiply by***	**To find**
	Length			Length	
1 inch (in)	2.54	centimeters (cm)	1 centimeter (cm)	.39	inch (in)
3 feet (ft)	91.44	centimeters (cm)	1 centimeter (cm)	.03	feet (ft)
1 yard (yd)	.91	meters (m)	1 meter (m)	39.37	inches (in)
1 mile (mi)	1.61	kilometers (km)	1 meter (m)	1.10	yards (yd)
			1 kilometer (km)	.62	mile (mi)

Some Common Equivalents

English	*Metric*	*Metric*	*English*
	(approximate)		*(approximate)*
1 statute mile (mi)	1.61 km	1 kilometer (km)	3280 ft 9.6 in
		1000 meters (m)	3280 ft 9.6 in
		500 m	1640 ft 5 in
.62 statute mile	1 km	200 m	656 ft 2 in
1000 ft	.2 km	150 m	492 ft 1 in
5 ft	1.5 m	100 m	328 ft 1 in
8 ft	2.4 m	75 m	246 ft 1 in
10 ft	3.0 m	60 m	196 ft 10 in
12 ft	3.6 m	50 m	164 ft 0 in
16 ft	4.8 m	25 m	82 ft 0 in
20 ft	6.0 m	20 m	65 ft 7 in
24 ft	7.2 m	12 m	39 ft 5 in
30 ft	9.0 m	10 m	32 ft 10 in
40 ft	12.0 m	8 m	26 ft 2 in
50 ft	15.0 m	7 m	23 ft 0 in
60 ft	18.0 m	6 m	19 ft 8 in
		5 m	16 ft 5 in
		4.5 m	14 ft 10 in
		4.0 m	13 ft 1 in
		3.5 m	11 ft 6 in
		2.5 m	8 ft 2 in
		2.0 m	6 ft 7 in
		1.5 m	4 ft 11 in
		1.0 m	3 ft 4 in
		.9 m	35.4 in
		.6 m	23.6 in
		.5 m	19.7 in
		1 centimeter (cm)	.39 in
		300 millimeters (mm)	11.8 in
		200 mm	7.9 in

[†] Approximate conversions from English to Metric measures and Metric to English measures.

Temperature Conversions

Fahrenheit to Celsius: To convert Fahrenheit temperatures to Celsius temperatures, subtract 32 from the Fahrenheit temperature and multiply the remainder by 5/9.		***Celsius to Fahrenheit:*** To convert Celsius temperatures to Fahrenheit temperatures, multiply the Celsius temperature by 9/5 and add 32 to the remainder.	
Fahrenheit Temperature (°F)	Celsius Temperature (°C)	Celsius Temperature (°C)	Fahrenheit Temperature (°F)
0°	- 18°	- 20°	- 4°
20°	- 7°	- 10°	14°
32°	0°	0°	32°
50°	10°	10°	50°
68°	20°	20°	68°
80°	27°	30°	86°
100°	38°	40°	104°
212°	100°	100°	212°

Glossary

A

abaft
Toward the rear (stern) of the boat. Behind.

abeam
At right angles to the keel of the boat, but not on the boat.

adrift
Floating loose, not on moorings or towline.

aft
At the stern or back of a vessel.

aground
A vessel touching or fast to the bottom.

Aid To Navigation (ATON)
Any device external to a vessel or aircraft specifically intended to assist navigators in determining their positions or safe courses, or to warn them of dangers or obstructions to navigation.

altocumulus clouds
"Piled up" clouds at middle altitudes.

anchor bend
A most secure knot for bending a line to an object.

articulated beacon
A beacon–like buoyant structure, tethered directly to the seabed and having no watch circle. Called articulated light or articulated daybeacon, as appropriate.

astern
Behind the vessel. Direction of movement, opposite of ahead.

athwartships
Across or at right angle to the centerline of a boat; rowboat seats are generally placed athwartships (thwarts).

B

barometer
An instrument for measuring the air pressure.

beam
The greatest width of the boat.

bearing
The direction to an object, given as a horizontal angle from a line of reference.

becket
A looped rope, hook and eye, strap or grommet used for holding ropes, wires or spars in position.

belay
To make a line fast. Also a command to stop.

bend
To attach a line to another line. Also, to attach a line to a spar or stay.

bight
A long and gradual bend or recess in the coastline that forms a large, open receding bay. Also, a bend in a river or mountain range. Also, a curve made in a rope by doubling it back on itself.

bilge
The lowest spaces in a vessel's hull.

bitt
A heavy and firmly mounted piece of wood or metal used for securing lines.

bitter end
The inboard end of a rope or cable.

block
A device consisting of a case enclosing one or more sheaves through which a line may be led to increase mechanical advantage or to change direction.

boathook
A pole with a hook or spike at the end, commonly used to facilitate line handling.

bollard
A heavy post set into the edge of a wharf or pier to which the lines of a ship may be made fast.

bolt rope
Line attached to the foot and luff of a sail to give it strength or to enable it to be attached to the spars.

boom
A spar attached horizontally to the mast for extending the foot of the sail.

boomkin
A short spar or structure projecting from the stern of a vessel to which the mizzen sail is sheeted.

bow line
A docking line leading from the bow.

bowline
A knot used to form a temporary eye in the end of a line.

bowsprit
A spar extending forward from the bow.

broach
The uncontrolled turning of a boat parallel to the waves, subjecting it to possible capsizing.

broad on the bow
A direction midway between abeam and dead ahead.

buoy
A floating object of defined shape and color, which is anchored at a given position and serves as an aid to navigation.

C

capsize
To turn over.

caulk
To stop up and make watertight by filling with a waterproof compound or material.

cavitation
The rapid building and subsequent explosion of bubbles caused by and interfering with the action of the propeller. Destroys lift, and can actually damage the metal of the propeller and supports.

centerboard
A plate, in a vertical fore-and-aft plane, that is pivoted at the lower forward end, and can be lowered or raised through a slot in the bottom of the boat to reduce leeway; movable keel used by sailboats.

chock
A fitting through which anchor or mooring lines are led. May be open or closed.

cleat
A fitting to which lines are made fast. The classic cleat to which lines are belayed is approximately anvil-shaped.

clew
The after, lower corner of a sail.

clove hitch
A knot for temporarily fastening a line to a spar, ring, post or piling.

coil
To lay a line down in circular turns.

COLREGS, 72
The International Regulations for Preventing Collisions at Sea, 1972, commonly called the International Rules.

compass rose
A circle graduated in degrees, clockwise from 000° at true north to 360°. It may also be graduated in points. It is printed on nautical charts for determining directions.

Coriolis force
The deflective effect of the earth's rotation on an object in motion which causes it to divert to the right in the northern hemisphere.

cruiser
Somewhat more seaworthy craft that usually affords some sort of living quarters.

cuddy
A small shelter cabin in a boat.

cumulus clouds
Clouds with vertical development.

D

daggerboard
A plate, in a vertical fore-and-aft plane, which can be lowered through a slot in the bottom of a sailboat to reduce leeway.

Danforth anchor
A patented lightweight anchor characterized by long narrow twin flukes pivoted at one end of the relatively long shank.

datum
The technical term for the base line from which a chart's vertical measurements are made—heights of land or landmarks, or depths of water.

davits
Mechanical arms extending over the side or stern of a vessel, or over a sea wall, to raise or lower a smaller boat.

daybeacon
A fixed NAVAID structure having one or more daymarks, which is used in shallow water.

daymark
A signboard attached to a fixed NAVAID structure to convey navigational information presenting one of several standard shapes (square, triangle, rectangle, diamond, octagon) and colors (red, green, orange, yellow, or black). Daymarks usually have reflective material indicating their shapes.

dead ahead
A relative bearing of 000 degrees.

dead in the water
Adrift, floating with the current.

dead reckoning
The practice of estimating position by advancing a known position for course and distance run. The effects of wind and current are not considered in determining a position by dead reckoning.

deviation
The effect of the vessel's magnetic fields upon a compass. Deviation is the difference between the direction that the compass actually points and the direction that the compass would point if there were no magnetic fields aboard the vessel.

dike
A manmade structure projecting from the shore into a waterway to control shoaling and to maintain a navigable channel.

dinghy
A small open boat. A dinghy is often used as a tender for a larger craft.

directional light
A light illuminating a sector or very narrow angle and intended to mark a direction to be followed.

displacement hull
A type of hull that plows through the water, displacing a weight of water equal to its own weight, even when more power is added.

distress signal
MAYDAY, MAYDAY, MAYDAY.

diurnal
Having a period or cycle of approximately one tidal day. Thus the tide is said to be diurnal when only one high water and one low water occur during a tidal day, and the tidal current is said to be diurnal when there is a single flood and single ebb period in the tidal day. A rotary current is diurnal if it changes its direction through all points of the compass once each tidal day.

dividers
An instrument consisting of two pointed legs joined by a pivot, and used principally for measuring distances or coordinates. An instrument having one pointed leg and the other carrying a pen or pencil is called a drafting compass.

documentation
A special federal license or registration for a vessel. A vessel of 5 or more net tons, owned by a United States citizen, may be documented as a yacht. The process is administered by the U. S. Coast Guard.

dolphin
A structure consisting of a number of piles driven into the seabed or riverbed in a circular pattern and drawn together with wire rope. Used for mooring and to protect other structures.

double sheet bend
A secure knot used to tie together two lines of unequal diameter.

draft
The vertical depth from the bottom of the keel to the top of the water.

E

emergency position indicating radio beacon (EPIRB)
A device that emits a continuous radio signal alerting authorities to the existence of a distress situation and leading rescuers to the scene.

equator
Great circle formed by passing a plane perpendicular to the axis of rotation of the earth at a point 90° from the north and south poles.

eye splice
A permanent loop spliced in the end of a line.

F

fathom
A nautical measure of length, six feet, used for measuring water depth and length of anchor rode.

fender
A cushion, placed between boats, or between a boat and a pier, to prevent damage.

fiberglass
Resin reinforced with fibrous glass (or glass reinforced plastic) used in boat construction. Its forms are mat, cloth, woven roving, and chopped strands.

fid
A tapered, pointed tool used to separate strands of rope when splicing.

figure–eight knot
A knot in the form of a figure eight usually tied at the end of a line as a stopper to keep the end of the line from passing through a block or fairlead.

fisherman's bend
A hitch for making fast to a mooring buoy or spar or to the ring of an anchor.

fix
A known position determined by passing close aboard an object of known position or determined by the intersection of two or more lines of position (LOPs) adjusted to a common time, determined from terrestrial, electronic, and/or celestial data. The accuracy, or quality of a fix, is of great importance, especially in coastal waters, and is dependent on a number of factors.

fixed light
A light showing continuously and steadily, as opposed to a rhythmic light. (Do not confuse with "fixed" as used to differentiate from "floating.")

flashing light
A light in which the total duration of light in each period is clearly shorter than the total duration of darkness, and the flashes of light are all of equal duration. This term is commonly used for a light that exhibits only single flashes that are repeated at regular intervals.

flemish
A decorative method of coiling a line flat on the deck or dock.

float plan
A document that describes the route(s) and estimated time of arrival of a particular voyage. The float plan generally includes a description of the vessel, radio and safety equipment carried, planned stops, names of passengers, and other pertinent information.

floating aid to navigation
A buoy that is secured in its assigned position by a mooring.

flood current
The movement of a tidal current toward a shore or upstream in a tidal river or estuary. In the mixed type of reversing tidal current, the terms *greater flood* and *lesser flood* are applied respectively to the flood currents of greater and lesser speed of each day. The terms *maximum flood* and *minimum flood* are applied to the maximum and minimum speeds of a flood current having a speed that alternately increases and decreases without coming to a slack or reversing.

fluke
The flat palm-shaped or shovel-shaped part of an anchor that digs in to prevent dragging.

forward
Toward the bow of the boat.

front
The juncture or boundary between two air masses of different temperatures.

G

galley
The kitchen area of a boat.

give-way vessel
A term, from the Navigational Rules, used to describe the vessel that must yield to another in a situation where risk of collision exists. (Was formerly called "the burdened vessel.")

GPS
Global Positioning System, an electronic navigation system using satellites for worldwide coverage.

grapnel
A straight shank anchor with four or five curved claw-like arms and no stock; used mostly for recovering lost articles or objects.

ground tackle
A collective term for the anchor and its associated gear.

gunwale
The upper edge of a boat's sides.

H

half hitch
The simplest kind of hitch; a knot made by passing the end of the rope around the rope and then through the loop just made.

halyard
A line or wire used to hoist a spar, sail, or flag.

hatch
An opening in a boat's deck fitted with a watertight cover.

hawser
A heavy rope or cable used for mooring or towing.

head
A marine toilet. Also the upper corner of a triangular sail.

heading (HDG)
The instantaneous direction of a vessel's bow. It is expressed as the angular distance

relative to north, usually 000°, clockwise through 359°. Heading should not be confused with course. Heading is constantly changing as a vessel yaws back and forth across the course due to the effects of sea, wind, and steering error. Heading is expressed in degrees of either true, magnetic, or compass direction.

headway

The forward motion of a boat through the water. Opposite of sternway.

heave to

To bring a vessel up in a position where it will maintain little or no headway, usually with the bow into the wind or nearly so. To stop.

helm

The wheel or tiller controlling the rudder.

helmsperson

The person who steers the boat. (Helmsman is traditional name.)

hitch

A knot used to secure a rope to an object or to another rope.

hold

A compartment below deck in a large vessel, used solely for carrying cargo.

horse latitudes

Either of two belts or regions near 30°N and 30°S latitude characterized by high pressure, calms, and light baffling winds.

houseboat

A popular modification of the cruiser, which can offer all the conveniences of home.

hull identification number (HIN)

A number that includes the manufacturers identification code, hull serial number, date of certification, and model year, displayed on the boat's hull.

humidity

Moisture in the air.

hurricane

A large, tropical storm, measuring hundreds of miles in diameter, having steady winds in excess of 65 knots. It is called a typhoon on the Pacific Ocean and a cyclone when inland.

I

impeller

A rubber, neoprene, or stainless steel device within a water pump that pumps water and circulates it throughout a marine engine, or through the nozzle of a jet drive.

inboard-outboard powered

A propulsion arrangement that places the engine inside the boat against the transom. The drive shaft passes through the transom and into a stern-drive unit that resembles the lower half of an outboard motor and contains the reduction gear and propeller shaft.

inboard-powered

A propulsion arrangement in which the engine and reduction gear are mounted inside the hull, and power is transmitted to the propeller through a drive shaft that penetrates the hull.

Intracoastal Waterway (ICW)

An inland waterway that runs parallel to the Atlantic and Gulf Coasts from Manasquan Inlet on the New Jersey shore to Brownsville, Texas.

J

jet drive

A propulsion arrangement in which an inboard engine is used to drive a high capacity pump that forces water through a nozzle to achieve thrust. Steering is achieved by changing the direction of thrust.

jet ski

A personal watercraft that uses a jet drive instead of a propeller.

jib sheet

The line, usually paired, that controls the athwartships movement of the jib.

K

keel

The main structural member of a vessel running fore-and-aft; the backbone of a vessel.

knot (kn sometimes kt)

A measure of speed equal to one nautical mile (6076 feet) per hour.

knot

A fastening made by interweaving rope to form a stopper, to enclose or bind an object, to form a loop or a noose, to tie a small rope to an object, or to tie the ends of two small ropes together.

L

latitude
Angular distance north or south of the equator expressed in degrees from zero to ninety, and labeled north or south to indicate the direction of measurement, e.g., lat. 35°N.

lay
To "lay a mark" is to be able to reach it without tacking. The lay of a line is the direction in which its strands are twisted, usually to the right.

lead line
A weighted line used to measure the depth of the water.

leeward
The direction away from the wind. Opposite of windward.

line of position (LOP)
A line of bearing to a known origin or reference, upon which a vessel is assumed to be located. An LOP is determined by observation (visual bearing) or measurement (RDF, loran, radar, etc.). An LOP is assumed to be a straight line for visual bearings, or an arc of a circle (radar range), or part of some other curve such as a hyperbola (loran). LOPs resulting from visual observations (magnetic bearings) are generally converted to true bearings prior to plotting on a chart.

list
Continuous leaning of a vessel to one side.

longitude
Distance east or west of the prime meridian expressed in degrees from zero to 180° east or west, e.g., Long. 123°W.

long splice
A method of joining two ropes without increasing the diameter of the rope. Normally used when line must pass thru a block or over a fairlead without jamming.

loran
An acronym formed from the words LOng-RAnge Navigation and used to describe an electronic navigation system that uses a chain of transmitting stations to allow mariners and aviators having specialized receivers to determine their geographical positions

lubber's line
An index mark or permanent line on a compass, which is used to read the compass heading of a vessel.

M

magnetic compass
An instrument for indicating any horizontal reference direction relative to the earth's magnetic field and magnetic north. It is equipped with a graduated compass card (which is balanced and is free to turn in a horizontal plane), and a lubber's line, which serves as a reference point for direction indication. A sailor's most common and most reliable direction-indicating device.

marlinspike
A spike for opening the strands of a rope while splicing.

mayday (MAYDAY is spoken three times)
A distress signal given to indicate that a mobile station is threatened by grave and imminent danger and requests immediate assistance.

mean high water (MHW)
A tidal datum that is the average of all high water heights observed over a specific 19-year cycle.

mean lower low water (MLLW)
A tidal datum that is the average of the lowest low water heights of each tidal day observed over a specific 19-year cycle.

Mercator projection
The projection technique most commonly used in the production of navigational charts. This is a cylindrical projection ingeniously modified by expanding the scale at increasing latitudes to preserve directions and to maintain the correct relationships between the latitude and longitude scales.

meridian (geographic meridian)
A great circle of the earth passing through both the geographic poles and any given point on the earth's surface.

mixed tide
Type of tide with a large inequality in the high or low or both water heights, with two high waters and two low waters usually occurring each tidal day. Actually, all tides are mixed, but the name is usually applied to the tides intermediate to those predominantly semidiurnal and those predominantly diurnal.

mooring
An arrangement for securing a boat to a mooring buoy or a pier; also anchored.

mushroom anchor
A stockless anchor with a cast iron bowl at the end of the shank; used principally in large sizes for permanent moorings.

N

nautical mile (M)
One minute of latitude; approximately 6076 feet—about 1/8 longer than the statute mile of 5280 feet.

navigable waters
The seas and waters that provide a "road" for transportation between two or more states or to the sea.

Navigation Rules
Regulations governing the movement of vessels in relation to each other, formerly "Rules of the Road."

no wake
Slow your vessel so it does not make either a bow or stern wake; usually this means the vessel is off plane and level in the water.

Northill anchor
This anchor has a stock at the crown instead of at the head. The arm is at right angles to the shank and the broad flukes are set at an angle carefully designed to assure a quick bite and penetration of the bottom.

O

occulting light
A light in which the total duration of light in each period is clearly longer than the total duration of darkness and in which the intervals of darkness (occultations) are all of equal duration. (Commonly used for single-occulting light that exhibits only single occultations, which are repeated at regular intervals.)

outboard
Toward or beyond the boat's sides, opposite of inboard. A detachable engine mounted on a boat's stern.

outboard-powered
The engine is mounted outside the hull on the transom.

P

painter
A line attached to the bow of a small boat for use in towing or making fast.

pan pan (spoken three times)
The urgency signal used when the safety of the vessel or person is in jeopardy.

parallel of latitude
Any of the imaginary lines parallel to the equator and representing latitude.

parallel rules
An instrument for transferring a line parallel to itself, used in chartwork for drawing and measuring courses or bearings.

part
To sever or otherwise break apart.

pay out
To ease out a line, or let it run in a controlled manner.

pendant (also pendent)
A line by which a boat is made fast to a buoy.

pennant
A small flag, most often a signal flag.

Personal Flotation Device (PFD)
A life jacket that, when properly used, will support a person in the water. Available in several sizes and types.

piloting
Piloting is navigation involving frequent or continuous reference to charted objects and landmarks, ATONs, and depth soundings.

pitchpoling
A boat being thrown end-over-end in rough seas.

pivot point
A point somewhat aft of the bow, somewhere forward of the midpoint. To an observer on board, a vessel appears to turn about its pivot point.

planing
A boat is said to be planing when its displacement decreases, it lifts itself over its bow wave, and it moves on the top of the water at high speeds.

polyconic projection
A map or chart projection in which the earth is projected on a series of cones concentric with the earth's axis and tangent to the sphere of the earth. Charts of the Great Lakes are typically based on the polyconic projection.

polyester rope
A synthetic fiber rope often used for sheets and halyards; aka Dacron, Terylene, etc.

polypropylene rope
The least costly of the common synthetic ropes; major advantage is that it floats.

port
The left side of a boat looking forward. A harbor.

position
On the earth this refers to the actual geographic location of a vessel defined by two parameters called coordinates. Those customarily used are latitude and longitude. Position may also be expressed as a bearing and distance from an object, the position of which is known.

pram
A small utility boat (8-10' long) with a wide beam relative to its length; used as a tender.

preferred channel mark
An aid to navigation that indicates a channel junction or bifurcation between a main (preferred) and a subordinate channel. Its color scheme and its light characteristics or its shape assist the navigator in identifying the preferred channel.

prime meridian
The meridian passing through Greenwich, England, from which both east and west longitude are measured, i.e., the zero degree meridian.

prowords
Oral shorthand of common radio words and phrases.

pulpit
A platform built forward of a vessel's bow; currently used to assist in raising or lowering an anchor but formerly the place where a harpooner stood.

Q

quarter
The sides of a boat aft of amidships.

quick light
A light more than 50 but less than 80 flashes per minute. (Previously called quick flashing light.)

R

radar
Self-contained navigation and collision avoidance system consisting of a shipboard transmitter and receiver. The transmitter transmits briefly, then shuts off to permit the receiver to "listen" for the reflected transmission or echo.

radio beacons
Transmitting stations used for RDF (see *radio direction finding*) system. Marine radio beacons operate in the 285 to 325 kilohertz band. As of this writing there are two types of radio beacons, continuous and sequenced.

radio direction finding (RDF)
Older short-range radio navigation system consisting of a series of land-based stations broadcasting in the LF/MF band and onboard receivers with directional antennas. Use of the directional antenna enables relative bearings to be determined, and, by simple conversion, lines of position.

range
The distance in nautical miles that the vessel can travel with the available fuel on board. The range may or may not include an allowance for a fuel reserve. Range is a function of throttle setting and other factors.

ranges
A pair of ATONs placed a suitable distance apart, with the far daymark mounted higher than the near one. When the range marks are in line, the vessel is in the channel. Ranges can also be established by any charted objects.

reciprocal bearing or course
A bearing or course that differs from the original by 180 degrees.

reciprocal direction
Corresponding but reversed direction.

red sector
A sector of the circle of visibility of a navigational light in which a red light is exhibited. Such sectors are designated by their limiting bearings, as observed at some point other than the light. Red sectors are often located such that they warn of danger to vessels.

regulatory marks
A white and orange aid to navigation with no lateral significance. Used to indicate a special meaning to the mariner, such as danger, restricted operations, or exclusion area.

restricted visibility
Any condition in which visibility is restricted

by fog, mist, falling snow, heavy rainstorms, sandstorms, or other similar causes.

rigging
The general term for all the lines of a vessel.

rudder
A vertical plate or board which can be pivoted to steer a boat.

runabout
A small, sporty craft intended for general use such as day cruising, water skiing, and fishing.

running rigging
Sheets, halyards, topping lifts, downhauls, vangs, etc., used for raising and adjusting sails (see standing rigging).

S

safety signal-radio
A radio signal used for messages concerning the safety of navigation or giving important meteorological warnings (pronounced SAY-CURITAY).

samson post
A single bitt in the bow or stern of a boat, secured to a structural member, usually the keel.

SATNAV
Satellite navigation system.

scope
The ratio of the length of anchor line deployed to the depth of the water, including the distance from the vessel's bow to the water.

seaworthy
A boat or a boat's gear able to meet the usual sea conditions.

security (see safety signal-radio)

semidiurnal
Having a period or cycle of approximately one-half of a tidal day. The predominating type of tide throughout the world is semidiurnal, with two high waters and two low waters each tidal day. The tidal current is said to be semidiurnal when there are two flood and two ebb periods each day.

72 COLREGS (see COLREGS)

shackle
A "U" shaped connector with a pin or bolt across the open end.

sheet
The line used to control the forward or athwartships movement of a sail.

sheet bend
A bend used to join two ropes of unequal size. Functionally different from a square knot in that it should be used between lines of different diameters.

short splice
A method of permanently joining the ends of two ropes.

shroud
The standing rigging that supports the mast at the sides of the boat.

skiff
A utility boat, flat-bottomed with either straight or slightly flared sides.

spar
A general term for masts, yards, booms, etc.

speed curve
A curve relating the vessel's speed through the water to the engine's throttle setting expressed in revolutions per minute (RPM).

spinnaker
A large, light-weather headsail used for running or reaching.

spring line
A fore-and-aft line used in docking, undocking, or to prevent the boat from moving forward or astern while made fast to a dock.

squall
A sudden, violent wind often accompanied by rain.

stand-on vessel
That vessel which continues its course in the same direction at the same speed during a crossing or overtaking situation, unless a collision appears imminent. (Was formerly called "the privileged vessel.")

standing part
That part of a line which is made fast. The main part of a line as distinguished from the bight and the bitter end.

starboard
The right side of a boat when looking forward.

stay
That part of the standing rigging supporting the mast from forward and aft.

stem
The foremost upright timber of a vessel to which the keel and ends of the planks are attached. The forwardmost part of the bow.

stern
The after part of the boat.

stratus clouds
Air masses that are lifted gently and evenly form clouds that are even, flat, and layered.

swamp
To fill with water, but not settle to the bottom.

swells
Relatively long wind waves that have traveled out of the generating area. They exhibit more regular and longer periods (distances between swells) and flatter crests.

T

tachometer
An instrument that indicates the speed of the engine measured in revolutions per minute (RPMs).

tack
To come about; the lower forward corner of a sail; sailing with the wind on a given side of the boat, as starboard or port tack.

tacking
Moving the boat's bow through the wind's eye from close–hauled on one tack to close–hauled on the other tack. Same as coming about.

thwart
A seat or brace running laterally across a boat.

tiller
A bar or handle for turning a boat's rudder or an outboard motor.

transom
The stern cross-section of a square–sterned boat.

trawler
A general term to describe a non commercial vessel with a displacement or semi-displacement hull designed for long distance cruising. Trawlers often resemble fishing vessels of the same name.

turnbuckle
A threaded fitting to pull two eyes together for adjustment of standing rigging.

twin propellers (screws)
A boat equipped with two engines and two propellers.

U

underway
A vessel not at anchor, made fast to a pier or wharf, or aground.

Uniform State Waterway Marking System (USWMS)
A system of marks to supplement the federal system in marking of state waters; a system of regulatory markers to warn a vessel operator of dangers and to provide general information and directions.

urgency signal-radio
See PAN PAN (pronounced PAHN PAHN).

utility outboard
A boat specifically designed for outboard motors.

V

variation
The angular difference between the magnetic meridian and the geographic meridian at a particular location.

very high frequency radio (VHF)
Radio frequency of 30 MHz to 300 MHz. The VHF system is essentially a line–of–sight system limited in range to only a little beyond the horizon.

visual distress signal (VDS)
A signal to attract attention and to guide rescuers in a search–and–rescue situation.

W

wake
Moving waves, track or path that a boat leaves behind it when moving across the waters.

wharf
A man-made structure bounding the edge of a dock and built along or at an angle to the shoreline, used for loading, unloading, or tying up vessels.

whipping
The act of wrapping the end of a piece of rope to prevent it from fraying.

winch
A device to increase hauling power when raising or trimming sails, adjusting tows, or weighing anchor.

windward
Toward the direction from which the wind is coming.

wing dam
A dam constructed to maintain a clear channel and control the random meandering of sandbars.

Index

A

abaft 6-5
abaft the beam 6-6
abeam 1-2, 6-6
accidents
  causes 13-1
  duties in case of 2-18
  reports 2-21
adrift 1-3, 6-2
aft 1-1
aground 1-3
Aids to Navigation (ATONS)
  cardinal system 12-5
  electronic 5-14
  inland 12-3
  piloting aids 7-7
  protection of 5-1
  tying to 5-1
  Western Rivers 12-3
air circulation, global 10-4
air masses 10-6
amateur radio service 11-2
anchor(s)
  Danforth 4-17
  grapnel 4-18
  heavy weather 4-19
  lunch hook 4-19
  mushroom 4-18
  need 2-17
  Northill 4-18
  parts 4-18
  plow 4-19
  rode 4-17
  scope 4-19
  weighing 4-21
  Yachtsman's 4-18
anchored 1-3
anchoring 4-17, 4-20
anchoring area, special 6-19
anti-fouling paint 1-9
athwartship 1-2, 4-8
auxiliary motors 4-7

B

barges 6-3
barometer 10-8
battery 8-10
  charge 8-11
  charging 8-13
  corroded terminals 8-12
  failure 8-11
  securing 8-12
  short circuits 8-12
  switch 8-11
beam 1-5
Bearing Buddy 3-5
bend (knot) 9-9
  anchor 9-12
  becket 9-11
  double sheet 9-11
  fisherman's 9-12
  sheet 9-11
  slippery sheet 9-11
bitt 9-9, 9-18
boat
  bass 1-2
  length 2-3
  maintenance 8-14
  sales 2-2
  steering 4-10
  transfers 2-2
  utility 1-5
boathook 4-10
boom 9-4, 9-10
boomkin 2-3
bow 1-2
bow rail 1-6
bow wave 1-4
bowrider 1-6
bowriding 1-6
bowsprit 2-3
breezes 10-4
briefing guests 4-8. *See also* crew training
broaching 4-23
broad on the bow 4-22
buoyage systems 5-1
buoys 5-2, 5-3, 5-4
  chart symbols 5-2, 5-11
  floating structures 5-3
  river 12-4
Buys-Ballot's law 10-7

C

canals 12-2
capsize 4-8
carbon monoxide 2-5, 2-9
  and ventilation 13-16
carbon monoxide poisoning 13-15
cathedral hull 1-6
caulking 1-9
cavitation 4-4
center console
center of buoyancy 13-2
center of gravity 4-9, 13-2
chart symbols 5-5, 5-7, 5-11
charts
  abbreviations 7-6
  availability 7-2
  coastal 7-3
  dates of 7-2
  harbor 7-3
  information block 7-4
  Missouri River 12-20
  nautical 7-2
  notes 7-7
  projections 7-2
  river 12-18
  scales 7-3
  shore details 7-7
  strip 7-4
  symbols 7-6
  water depths 7-5, 7-6
chine 1-2
chocks 9-18
cleats 9-16, 9-17
clew 9-13
clouds 10-9, 10-10
Coast Guard Auxiliary. *See* U.S. Coast Guard Auxiliary
Coast Guard Customer Infoline 1-11
cold front clouds 10-10
collision course 6-6
Columbus 10-6
compass rose 7-12
composite tows 12-22

construction materials 1-8
  aluminum 1-5, 1-8
  fiberglass 1-8
  steel 1-8
  wood 1-9
coriolis force 10-5
Courtesy Marine Examination 2-21
cowl 2-5
crankcase 8-2
crew training. *See also* briefing guests
  fire extinguishers 2-9
  launching 3-12
  life jackets 2-13
  "man" overboard 4-9, 4-14
  radio 11-17
  vessel operation 4-9
crossing daymarks 5-5, 12-3, 12-22
crossing situations 6-6, 6-10
  inland 6-10
  international 6-10
cruiser 1-5, 1-7
cuddy cabin 1-7
cushion 2-10
cyclones 10-17

D

danger zone 6-5
datum 7-4
  horizontal 7-4
  vertical 7-5
davits 1-5
daybeacons 5-4
  river 12-20
daymarks 5-4
  crossing 12-3
  diamond shaped 5-5
  passing 12-3
  square 5-4
  triangular 5-4
dead ahead 6-5
dead in the water 1-3
dead reckoning 7-19
deadrise 1-2
demarcation lines 6-2
deviation 7-13
  compass 7-13
  table 7-14
dewatering device 2-17
dinghy 1-5
dip the eye 9-20
direction
  measuring 7-12
  on a chart 7-12
distance
  computation 7-18
  measuring 7-11
  on a chart 7-11
distress signals 6-20
docking 4-15
documentation 1-12, 2-1
downbound 6-4
draft 1-2, 1-7
dredge
  lights 12-9
  shapes 12-9
dredging 12-9

E

electrical dangers 8-13
  direct current 8-13
  prevention 8-14
electrolysis 1-9
Emergency Position Indicating Radio Beacon (EPIRB) 2-16
engine
  carburetors 8-6
  diesel 8-2
  direct drive 8-3
  four-cycle 8-1
  inboard 1-7, 4-5, 8-3
  internal combustion 8-1
  jet drive 1-8, 4-8
  outboard 1-3, 8-4
  size 8-5
  stern drive 1-3, 8-4
  troubleshooting 8-19
  tunnel drive 1-8, 8-4
  two-cycle 8-1
  types 8-1
  v-drive 8-3
  variable ratio oilers (VRO) 8-2
engine maintenance
  fittings 8-15
  fuel system 8-16
  hydraulic fluid 8-15
  ignition system 8-16
  lubrication 8-14
  routine 8-14
  spring fitting-out 8-19
  water separation filter 8-16
  winterizing 8-17
environmental concerns
  improper anchoring 4-20
  zebra mussels 3-17, 8-8, 12-24
equipment not required but recommended 2-17

F

falling overboard 4-14
Federal Communications Commission (FCC)
  rules 11-9
  rules violations 11-9
fiberglass 1-5
  disadvantages 1-11
fiberglass construction 1-9
  chopped-strand 1-9
  hand-layup 1-9
  matched-die 1-10
  sandwich 1-10
fire extinguisher 2-7, 3-6
  approved 2-7, 2-8
  care & treatment 2-8
  contents 2-7
  halon 2-7
  legal requirements 2-9
  obsolete 2-8
  sizes 2-7
  using 2-9
fires, types 2-7
first aid kit 2-17
fitting 2-3
fix 7-15
flame arrester, backfire 2-6, 8-20
float plan 3-17
float-on trailer 3-4
flotation 13-3
flotation aids 2-10
fog 10-11, 10-12
forward 1-1
freeboard 1-2
fronts 10-7, 10-8
fuel lines 8-10
fuel tanks 4-2, 8-10
  vents 4-2
fueling a boat 4-1

G

galley 1-7
galvanic action 8-17
garbage disposal 2-19
gasoline 8-8
  and alcohol 8-9
  and fuel systems 8-10
  and outboards 8-9
  leaded 8-8
  octane rating 8-9
  premium 8-9
General Prudential Rule 6-3
General Responsibility Rule 6-3
give-way 6-5
Global Positioning System (GPS) 5-15
Good Samaritan clause 2-18
Great Circle 7-8
gunwale 1-2

H

halyard 9-1

"ham" 11-2
hatch 1-7
hazards
  changing water depths 12-5
  lakes 12-5
  overhead 12-5
  underwater 12-6
head 1-7
  maintenance 8-19
heading 7-14
heat and air pressure 10-4
heaving line 4-10
helm 1-6
HELP position 13-8
high dams 12-12
  fishing below 12-13
  gates 12-13
  restricted areas 12-12
hitch 9-9
  clove 9-11
  half 9-12
  rolling 9-13
  two half hitches 9-12
  weather 9-16
houseboat 1-5, 1-8
hull
  cathedral 1-6
  displacement 1-4
  planing 1-4
  semi-displacement 1-5
hull identification number (HIN) 2-2
hurricanes 10-17
hydrometer 8-11
hydroplane 1-2
hypothermia 4-9, 12-6, 13-6
  activity and 13-7
  prevention 13-7
  stages in 13-6

I

I/O 1-3
idle speed 4-11, 4-13
ignition protection 2-6, 4-1
ignition systems 8-6
  alternator-battery 8-6
  electronic ignition 8-7
  magneto 8-6
impeller 3-13, 8-8
inboard/outboard 1-3
induction system 8-6
inflatables 1-5
informational daymarks 5-5, 5-6
inland navigation 12-2
inlets 4-24
installing a radio 11-6
Intracoastal Waterway (ICW) 5-1, 5-2, 5-5, 5-6, 5-9
isolated danger marks 5-2

J

jet drive 1-8, 4-8
jet ski 1-8
jon boat 1-5

K

keel 1-2
kill switch 2-20, 13-5
knot. *See also* bend, hitch
  bowline 9-13
  figure eight 9-10
  line strength 9-9
  overhand 9-10
  parts 9-9
  reef 9-10
  sheet 9-11
  stopper 9-10
knot (speed measure) 7-10, 7-17

L

lakes 12-2
land breeze 10-4
language
  boaters' 1-1
  origins 1-1
larboard 1-1
lateral marks 5-2, 5-7
latitude 7-8
  parallels 7-8
launching a boat 3-13
  preparing 3-12
  retrieving 3-14
lay to 4-23
leaving a pier 4-11
left bank 12-3
legal requirements 2-1
levees 12-8
life jacket 2-10, 4-10
  care of 2-13
  general considerations 2-13
  legal requirements 2-12
  Type I 2-10
  Type II 2-10
  Type III 2-10
  Type IV 2-10
  Type V 2-11
lighthouse 5-5
lighthouse sectors 5-12
lightning 10-14
lights
  all-round 6-13
  articulated 5-11
  bridge 5-14, 6-20
  characteristics 5-10
  fixed 5-10
  fixed structure 5-11
  flashing 5-10
  isophase 5-10
  occulting 5-10
  patterns 5-10
  preferred 5-11
  quick 5-10
  river navigation 12-22
  safe water 5-11
  structures 5-12
lights on vessels 6-14
  at anchor 6-19
  constrained by draft 6-18
  diving 6-19
  fishing 6-17
  navigation 6-13
  power 6-17
  sailing 6-14
  sidelights 6-5
  sternlight 6-5
  towing 6-18
line of position 7-15, 7-16
line of sight transmission 11-5
line parts 9-9
lines
  chafing 9-6
  cleaning 9-6
  fraying 9-6
  lead 9-1
  mooring 4-15
  overstressed 9-5
  stowing 9-6
  whipping 9-6
load board 1-1
lock operation 12-14
lockmaster 12-14
  communicating with 12-16
locks 12-14
  bollards 12-18
  commercial traffic 12-14
  hazardous cargo 12-15
  leaving 12-18
  locking through 12-17
  priorities for use 12-14
  rafting up 12-18
  traffic signals 12-16
  tying up 12-17
log 11-14
longitude 7-9
lookout 6-4
Loran C 5-14
lower unit 1-3
  care 8-15
lowhead dams 12-10
lubber's line 7-8

M

magnetic compass
  adjusting 7-8
  correcting 7-14
  error 7-13
  features 7-7
  installing 7-8
  rose 7-12
  variation 7-13
making up lines
  coiling 9-7
  faking 9-7, 9-8
  flemishing 9-7, 9-8
"man" overboard 4-9, 4-14, 13-13
manatee caution mark 5-6
maneuvering 4-11, 4-13
marine surveyor 1-12
marlinspike, defined 9-1
mean high water (MHW) 7-5
mean low water (MLW) 7-5
mean lower low water (MLLW) 7-5
meeting head-on 6-6, 6-7
meridian 7-9
  prime meridian 7-9
microburst 10-14
mile markers 12-4
minor lights 5-5
moored 1-3
mooring 4-16
motors. *See* engine

N

narrow channels 6-4
National Weather Service 4-9
Nautical Chart Catalog 7-2
nautical mile 7-10
navigable rivers 12-1
navigable waters 6-1
navigable waterways 12-2
navigation defined 7-1
navigation lights. *See* lights
navigation publications 5-16
Navigation Rules
  inland 6-1, 12-2
  international 6-1
  local waters 6-2
  sailboats 6-7, 13-12
near-shore buoyant vest 2-10
non-pyrotechnic signals 2-15
numbering of vessel 2-2

O

offshore life jacket 2-10
oil discharge 2-18
one-third rule 4-1
open diamond daymark 5-5
open fisherman 1-6
order of precedence 13-12
outboard engine 4-7
outboard motor 1-3. *See also* outboard engine
outdrive 1-3
overtaken vessel 6-6
overtaking vessel 6-6, 6-11

P

painter 9-1
parallel rulers 7-1, 7-12
pendant 4-17
personal flotation device. *See* life jacket
personal watercraft 1-5, 1-8, 13-3
PFD. *See* life jacket
piloting defined 7-1
pitchpoling 4-23
plane 1-4
planing 1-4
plate
  capacity 2-3
  compliance 2-4
plot, dead reckoning 7-19
plotting a course 7-12
pollution
  bilge oil 2-18, 8-15
  garbage 2-19
  gasoline spill 4-2
  halon 2-7
  marine sanitation device (MSD) 2-16
  oil discharge 2-18
  two-stroke engines 8-2
  zebra mussels 3-17, 8-8
pontoon boat 1-5, 1-7
port 1-1
portable fuel tank 2-6
position 7-8, 7-15
pounding 2-9
pram 1-5
preferred channel marks 5-2, 5-7
preparing to launch 3-12
prime meridian 7-9
projections, chart 7-2
  Mercator 7-2
  polyconic 7-3
propeller 1-6, 4-3
  diameter 4-3
  maintenance 8-17
  pitch 4-3
  selecting 4-4
  selection 8-5
  size 4-3
prowords 11-10
pulpit 2-3
PWC. *See* personal watercraft
pyrotechnic
  daytime 2-15
  nighttime 2-16

Q

quarter 4-22

R

radar 6-4, 7-1
radio
  adjustment 11-6
  installation 11-6
  log 11-14
  repair 11-6
radio antenna 11-7
radio channels
  available 11-5
  bridge to bridge 11-8
  Coast Guard liaison 11-8
  digital selective calling 11-8
  intership safety 11-8
  maritime control 11-8
  needed 11-5
  port operations 11-8
  public correspondence 11-1, 11-6, 11-8
  weather 11-5
radio check 11-11
Radio Direction Finder (RDF) 5-15
radio language
  numbers 11-11
  obscenity, indecency, profanity 11-9
  phonetic alphabet 11-10
  procedure words 11-10
radio licenses 11-3
  amateur radio service 11-2, 11-4
  EPIRB 11-3
  inspection of 11-3
  operator 11-4
  posting of 11-3
  radar 11-3
  single-sideband 11-3
  station 11-3
  VHF-FM 11-3
radio navigation information 5-16
radio operation
  calling another station 11-9
  limited coast stations 11-10
  public correspondence calls 11-10
  push-to-talk 11-7
  ship-to-ship calls 11-10
  shore-to-ship calls 11-10
  squelch control 11-7
  transceiver 11-7
  use on land 11-9

radio watch 11-7
radios
  cellular telephone 11-2
  citizen band (CB) 11-2
  single-sideband (SSB) 11-1
  VHF-FM 2-18, 11-1
radiotelephone alarm 11-13
range marks 5-2, 5-8
recommended equipment 2-17
red, right, returning 5-6
red sector
  lighthouse 5-12
  vessel 6-5
reefed sail 9-10
registration 1-12, 2-1
regulatory marks 5-2, 12-4
retrieving a boat 3-14
revetments 12-8
right bank 12-3
right-of-way 6-4
river bends 12-7
river channels 12-6
river currents 12-6
river navigation 12-20, 12-22
river tows 12-22
  blind spots 12-23
  communicating with 12-24
rode 4-17
roller supporting trailer 3-4
rope
  bolt 9-1
  braided 9-4
  care of 9-5
  double braided 9-4
  laid 9-3
  measuring 9-4
  single braided 9-4
  uncoiling 9-5
rope materials
  natural fibers 9-1
  nylon 9-2
  polyester 9-2
  polypropylene 9-2
  special 9-2
  synthetic fibers 9-1, 9-2
rope parts. *See also* line parts
rudder 1-1, 2-3
Rule of Good Seamanship 6-3
runabout 1-5, 1-6

S

sacrificial zincs 8-17
safe water marks 5-2, 5-7
safety messages
  distress 11-2, 11-12, 11-13
  distress communications form 11-15
  imposing silence 11-14
  mayday 11-13
  mayday relay 11-14
  security 11-12, 11-17
  urgency 11-2, 11-12, 11-16
sailboards 13-12
  righting 13-15
sailboat 1-5, 13-9
  anchoring 13-10
  mooring 13-10
  righting 13-14
  square rigged 13-9
  tacking 13-9
  unique problems 13-9
Sailing and Seamanship xiv
sailing rules 6-7
samson post 9-18
Satellite Navigation (SatNav) 5-14
sea breeze 10-4
seaworthy 1-7
secrecy of communication 11-9
selecting a VHF-FM
  audio output 11-4
  available channels 11-5
  current usage 11-6
  selectivity 11-4
  sensitivity 11-4
  signal strength 11-5
  type of tuner 11-4
shackle 4-17
shapes 6-14
  balls 6-14
  cones 6-14
  cylinders 6-14
  diamonds 6-14
  vessel
    at anchor 6-19
    constrained by draft 6-18
    diving 6-19
    fishing 6-17
    power driven 6-16
    sailing 6-14
    towing 6-18
shear pin 4-4
sheet 9-1
shock cord 9-2
shroud 9-1
signal suppression 11-5
signals, pyrotechnic
  daytime 2-15
  nighttime 2-16
signals, sound
  bend 6-12
  crossing 6-9
  drawbridge 6-20, 12-24
  meeting 6-8, 6-9
  overtaking 6-11
  prolonged blast 6-8
  restricted visibility 6-13
  short blast 6-8
  whistle 6-8
skid trailer 3-4
skiff 1-5
slow speed 4-13
small boat safety 13-1, 4-25
sound producing devices 2-14
spar 9-12
special marks 5-2, 5-6
speed 2-20
  computation 7-18
  curve 7-17
  measuring 7-17
  restricted 12-2
  safe 6-4
  table 7-17
spinnaker 9-10
splice 9-9, 9-14
  back 9-7
  eye 9-14
  long 9-14
  short 9-14
splicing
  double braided 9-15
  wire rope 9-15
squall line 10-8, 10-13
stability 1-2, 1-4, 13-2
stanchion 1-6
stand-on 6-5
starboard 1-1
stay with your boat 13-3
steering 1-3, 4-5
stern 1-1
stern drive engine 4-7
  tilt adjustment 4-7
storm distance 10-13
storm surge 10-3, 10-17
stringer 1-9, 3-4
substance abuse 2-20
swamp 1-2, 4-8
swells 10-3

T

table
  deviation 7-14
  speed 7-17
tachometer 7-17
tailrace 12-13
telltale 4-11
temperature
  and energy 10-6
  and humidity 10-6
tender 1-5

thimble 4-17
three point contact 13-3
throwable 2-10
thunderstorms 10-9, 10-12
thwart 2-7
tides 7-5, 7-6
tilt trailer 3-4
time, computation 7-18
tornadoes 10-15
Traffic Separation Scheme (TSS) 6-4
trailer
  backing 3-11
  balance 3-10
  ball 3-9
  bearings 3-5
  brakes 3-2, 3-8
  care 3-5
  coupler 3-9
  gross axle weight 3-4
  gross vehicle weight 3-3
  handling 3-11
  hitches 3-9
  license 3-2
  lights 3-2, 3-5
    failure 3-2
  mirrors 3-2
  pre-departure checks 3-12
  reflectors 3-2
  safety chains 3-3
  size 3-3
  storing 3-14
  theft prevention 3-15
  tie-downs 3-7
  tires 3-5
    changing 3-6
    life 3-5
    pressure 3-5
  tongue weight 3-10
  types 3-4
  width 3-1
  winch 3-7
transom 1-2
  cutaway 1-3
trawler 1-5
tropical disturbances 10-16
tropical storm winds 10-17
tug 6-3
tunnel drive 1-8
turnbuckle 9-17
twin screws 4-6

U

U.S. Aids to Navigation System 5-1, 5-2
underwater structures 12-9
underway 2-3
Uniform State Waterway Marking System (USWMS) 5-1,
United States Coast Guard xiii, 1-11
United States Coast Guard Auxiliary xiii, xiv
United States Power Squadrons xiii
utility outboard 1-5

V

VDS. *See* visual distress signals
ventilation 2-4
  open boats 2-4
  requirements 2-6
ventilation systems 2-5
vessel
  backing 4-11
  balancing the load 4-8
  constrained by draft 6-3
  definition 1-1, 6-2
  downbound 6-4
  fishing 6-2
  making way 6-2
  not making way 6-2
  not under command 6-3
  power driven 6-2
  restricted in ability to maneuver 6-2
  sailing 6-2
  underway 6-2
  upbound 6-4
Vessel Traffic Services (VTS) 6-5
VHF-FM radio 2-18, 4-9
visibility
  impaired 4-23
  restricted 6-4, 6-13
visual distress signals 2-14
  disposal of 2-16
  types 2-15

W

wake 4-11, 4-13, 5-5
walk-around cabin 1-7
walk-through windshield 1-6
warm front clouds 10-10
warnings
  gale 10-3
  hurricanes 10-17
  small craft 10-3, 10-8
  storm 10-3
  tropical storm 10-16
water skiing 4-21
wave height 10-3
waves
  and wind 10-3
  breaking 10-3
  height 10-3
  shallow water 10-4
  swells 10-3
weather
  and heat 10-4
  check 4-9
  heavy 4-22
  information 1-3, 4-9
  non-frontal 4-9
weather information sources 1-3, 4-9
  National Weather Service 10-1
  newspapers 10-1
  pennants, flags, lights 10-3
  radio 10-1
webbing 9-4
Western Rivers 5-2
  tides 7-6
Western Rivers System 5-1, 12-1
wharf 1-1
willy-nilly 10-17
winch 3-7, 9-19
windshear 10-9, 10-13
windward 6-7
wing dams 12-8
wire rope 9-3

Y

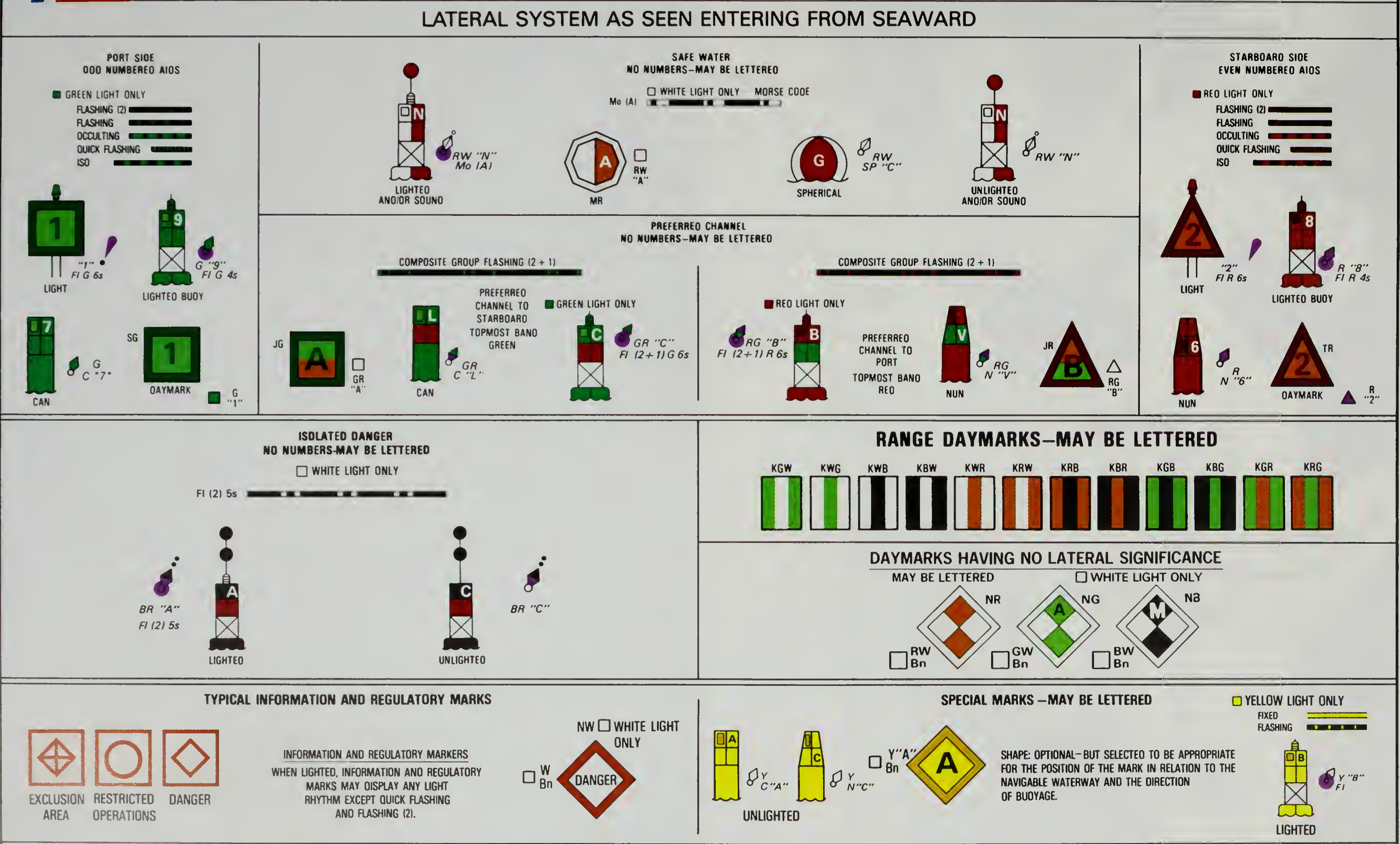
yaw 4-23
yellow triangles, squares, bands 5-9

Z

zebra mussels 3-17 12-24

U.S. AIDS TO NAVIGATION SYSTEM

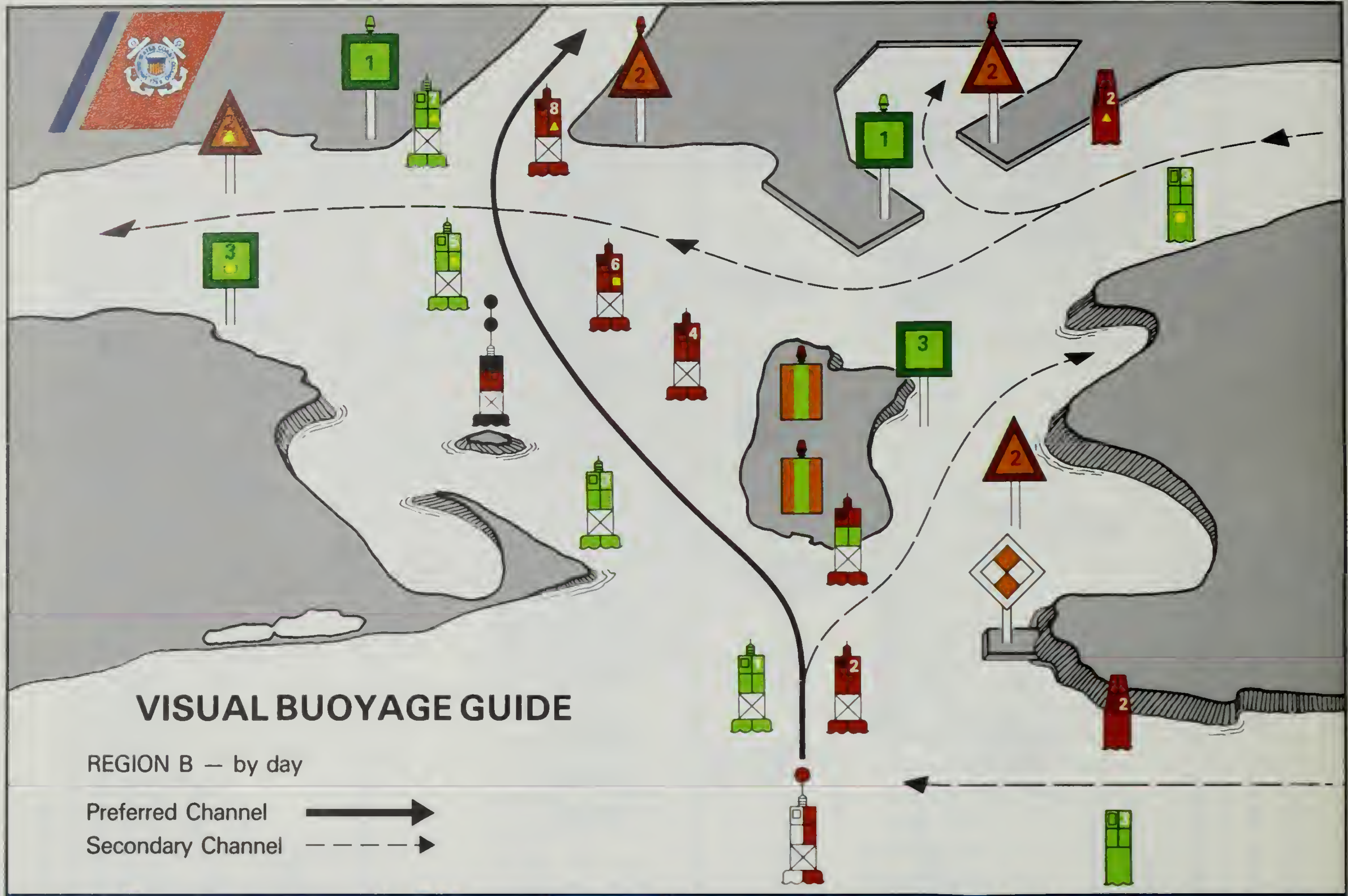
on navigable waters except Western Rivers



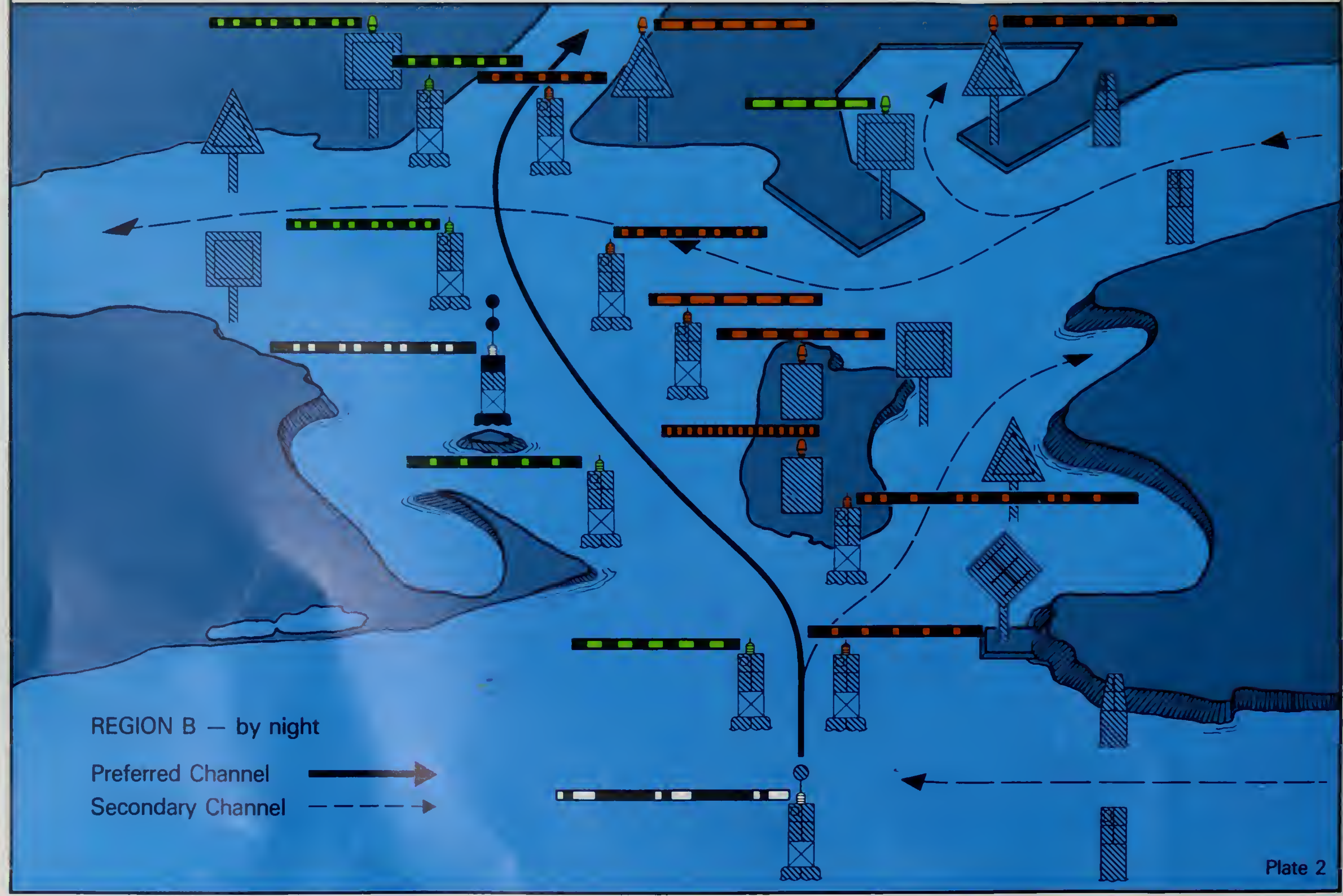
Aids to navigation marking the Intracoastal Waterway (ICW) display unique yellow symbols to distinguish them from aids marking other waters. Yellow triangles △ indicate aids should be passed by keeping them on the starboard (right) hand of the vessel. Yellow squares ☐ indicate aids should be passed by keeping them on the port (left) hand of the vessel. A yellow horizontal band ▭ provides no lateral information, but simply identifies aids as marking the ICW.

Plate 1

VISUAL BUOYAGE GUIDE



REGION B — by day



REGION B — by night

Plate 2

FICTITIOUS NAUTICAL CHART

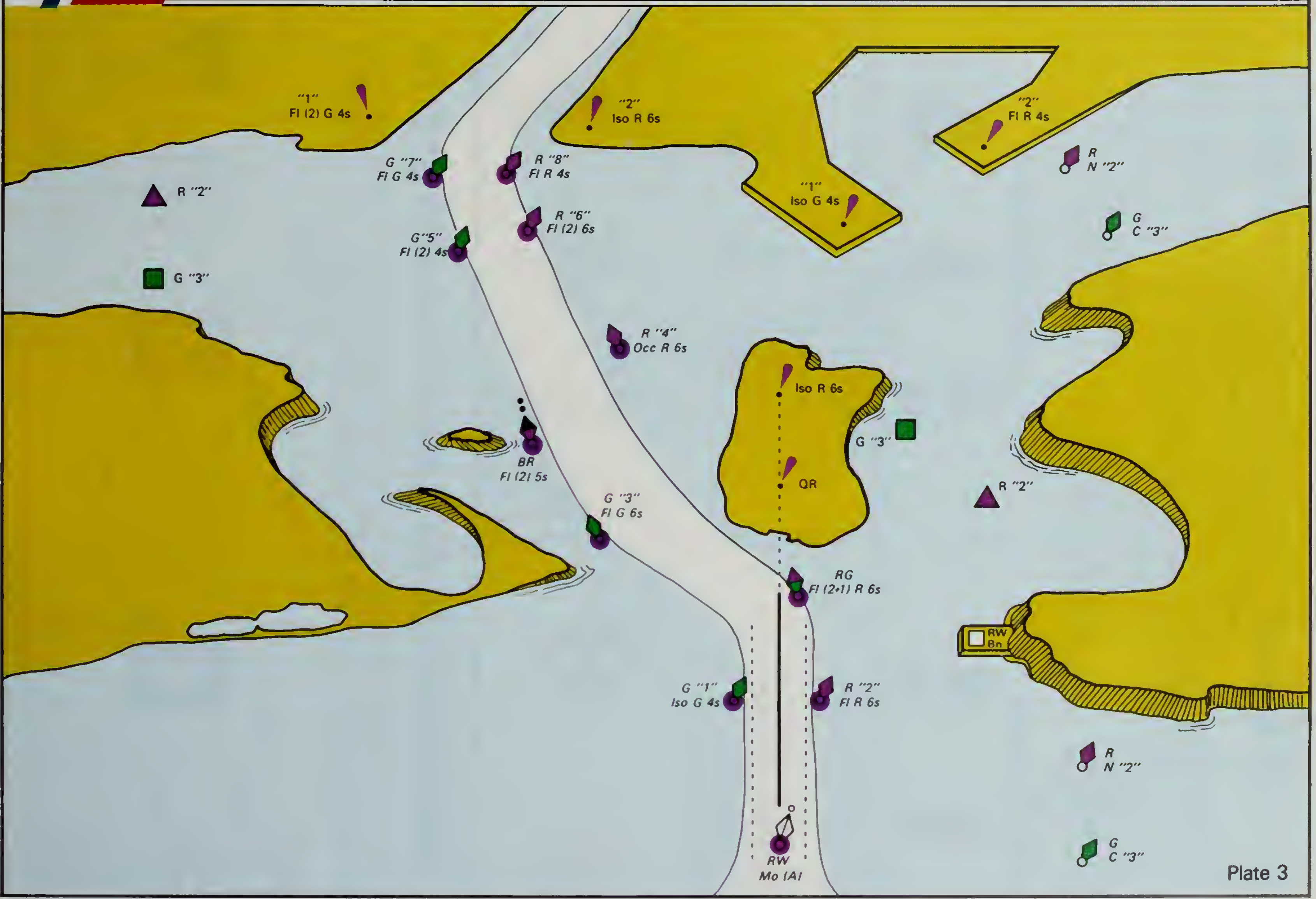
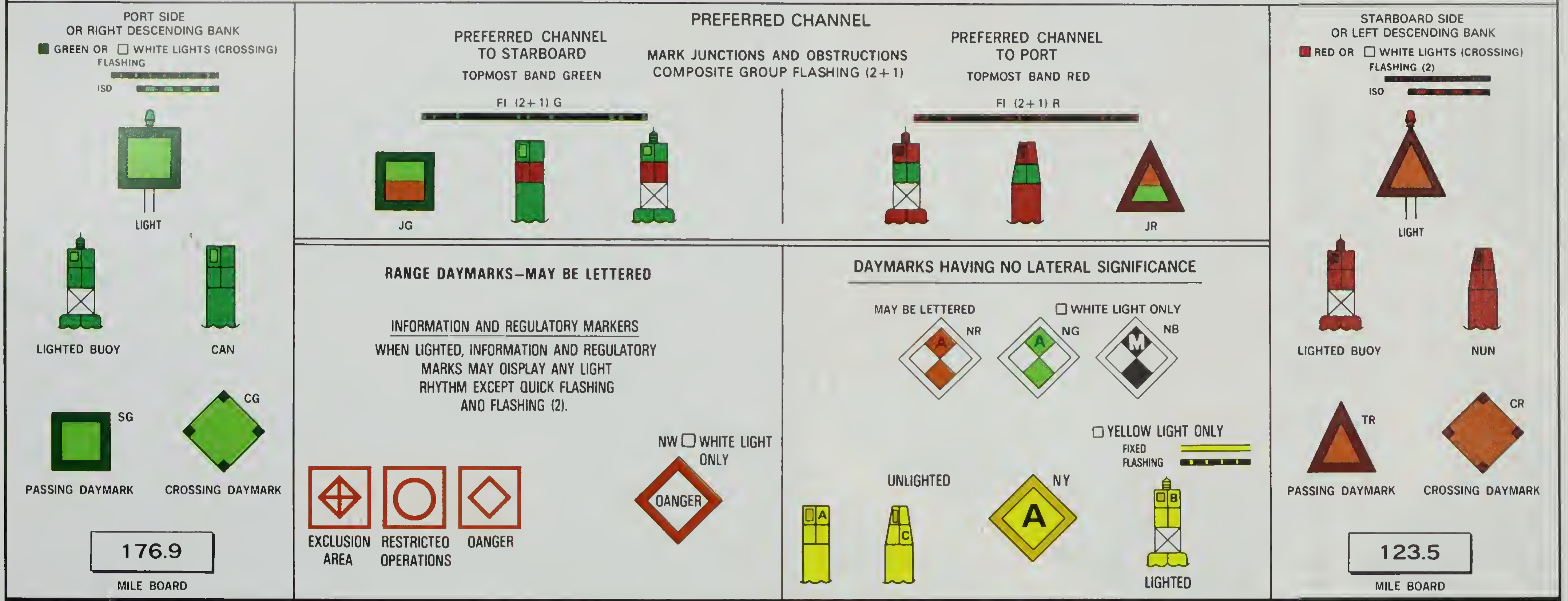


Plate 3

U.S. AIDS TO NAVIGATION SYSTEM

on the Western River System

AS SEEN ENTERING FROM SEAWARD



UNIFORM STATE WATERWAY MARKING SYSTEM

STATE WATERS AND DESIGNATED STATE WATERS FOR PRIVATE AIDS TO NAVIGATION

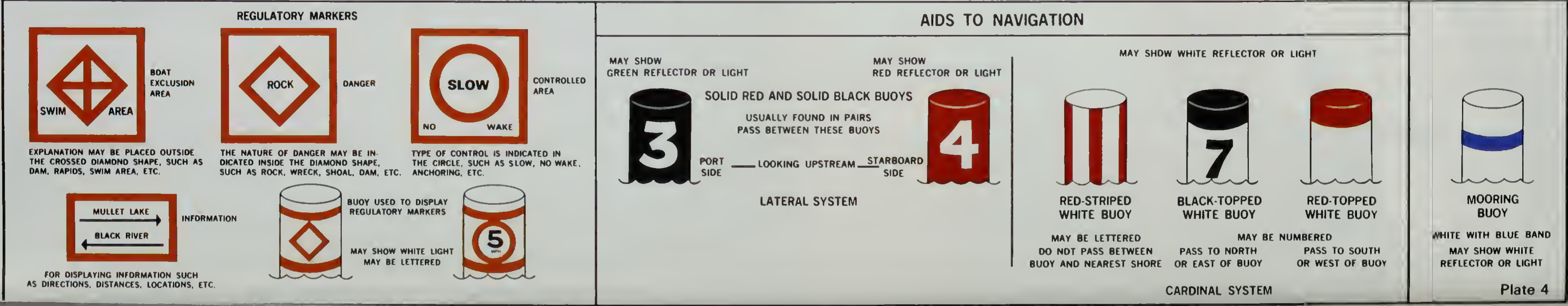

REGULATORY MARKERS
SWIM
AREA
BOAT EXCLUSION AREA
EXPLANATION MAY BE PLACED OUTSIDE THE CROSSED DIAMOND SHAPE, SUCH AS DAM, RAPIDS, SWIM AREA, ETC.
ROCK
DANGER
THE NATURE OF DANGER MAY BE INDICATED INSIDE THE DIAMOND SHAPE, SUCH AS ROCK, WRECK, SHOAL, DAM, ETC.
SLOW
NO
WAKE
CONTROLLED AREA
TYPE OF CONTROL IS INDICATED IN THE CIRCLE, SUCH AS SLOW, NO WAKE, ANCHORING, ETC.
MULLET LAKE
BLACK RIVER
INFORMATION
FOR DISPLAYING INFORMATION SUCH AS DIRECTIONS, DISTANCES, LOCATIONS, ETC.
BUOY USED TO DISPLAY REGULATORY MARKERS
5
MAY SHOW WHITE LIGHT
MAY BE LETTERED
AIDS TO NAVIGATION
MAY SHOW
GREEN REFLECTOR OR LIGHT
MAY SHOW
RED REFLECTOR OR LIGHT
SOLID RED AND SOLID BLACK BUOYS
USUALLY FOUND IN PAIRS
PASS BETWEEN THESE BUOYS
3
4
PORT SIDE
LOOKING UPSTREAM
STARBOARD SIDE
LATERAL SYSTEM
MAY SHOW WHITE REFLECTOR OR LIGHT
RED-STRIPED WHITE BUOY
7
BLACK-TOPPED WHITE BUOY
RED-TOPPED WHITE BUOY
MAY BE LETTERED
DO NOT PASS BETWEEN BUOY AND NEAREST SHORE
MAY BE NUMBERED
PASS TO NORTH OR EAST OF BUOY
PASS TO SOUTH OR WEST OF BUOY
CARDINAL SYSTEM
MOORING BUOY
WHITE WITH BLUE BAND
MAY SHOW WHITE REFLECTOR OR LIGHT

Plate 4

U.S. Coast Guard Auxiliary